THE

NEWCASTLE MEETING

OF THE

British Association

1889.

REPORT OF THE PROCEEDINGS

REPRINTED FROM THE

"Newcastle Daily Chronicle."

Q3
1889
B86N

Hewson, the Daily Chronicle

22102347634

62542

THE

NEWCASTLE MEETING

OF THE

British Association

1889.

REPORT OF THE PROCEEDINGS

REPRINTED FROM THE

"Newcastle Daily Chronicle."

Published for the Proprietors of the "Newcastle Daily Chronicle" by
WALTER SCOTT, NEWCASTLE-UPON-TYNE,
AND 24 WARWICK LANE, LONDON.

WELLCOME
HISTORICAL
MEDICAL
LIBRARY

31060217

WELLCOME INSTITUTE
LIBRARY
Coll. welMOmec
Call No. Q 3
1889
B 86n

The British Association in Newcastle.

The Meeting of 1889.

THE BRITISH ASSOCIATION.

ITS ORIGIN AND ITS WORK.

The British Association exists "for the advancement of science." That is the declared object which forms a part of its title ; and the purpose of the present article is to explain the circumstances which led to the founding of the association, to describe the method in which it pursues its lofty mission, and to show how far its history has borne out the hopes and expectations of those who assisted at its birth. To Sir David Brewster must be ascribed the credit of having taken the initiative in founding the institution. More than half a century ago the idea had taken possession of the minds of many entitled to rank as leaders of English thought that our country was gradually falling behind in the race of scientific progress, that there was wanting a proper stimulus to scientific research, and that something must be done to draw together workers in the various fields of investigation, to gather up the fruits of their labours and invest them with something of a national character. The project which Sir David Brewster conceived was a bold one, but it was destined to be crowned with such measure of success as its learned originator probably never anticipated. Dr. Brewster first put himself into communication with Mr. Phillips, one of the secretaries of the Yorkshire Philosophical Society. The council of the latter body fully entered into the spirit of the scheme, and it was energetically supported by Mr. (afterwards Sir Roderick) Murchison and other eminent men of the time, with the result that a meeting was convened to be held at York in the last week of September, 1831. Circulars of invitation were addressed to the presidents and secretaries of all the scientific institutions in England known to the committee, and also to a large number of active cultivators of science, whether belonging to any recognised society or not. The response to the invitation was most encouraging. The attendance numbered about 300, and included deputations from many provincial institutions. There were, in fact, representatives from Newcastle and Edinburgh in the North, from London in the South, and even from Bath, Bristol, and other places in the West of England. Two or three of the most eminent of those invited were, however, unable to attend this first gathering, owing to previous engagements, and amongst those so absent were Mr. Faraday and Dr. Buckland. After the usual preliminaries, the business of the first meeting was appropriately opened with an exposition of the objects and plan of the association, which was delivered by the Rev. Wm. Vernon Harcourt, who himself had much to do with bringing the association into existence. The address delivered on that occasion set forth the aims of the association eloquently and at considerable length. Yet there was nothing in what the speaker said which could be regarded as in any way superfluous, and even at this distance of time it is interesting to peruse, because of the evidence it affords of the clear insight and far reaching perception, as well as the genuine enthusiasm on behalf of science, which characterised the founders of the great body meeting in our midst to-day. It was pointed out in that address that the need of the age was an association which could give a "stronger impulse and a more systematic direction to scientific inquiry" than any of the institutions at that time in existence. The idea was to focus all the scientific strength of Great Britain, and to employ it for a short period in each year in marking the lines of direction along which the researches of science should move. Care was taken at the same time to show that in fulfilling these functions the new association would not interfere with the legitimate work of the Royal Society. These aims were embodied in a series of resolutions providing for the constitution and regulation of the society, and, on being put to the meeting in customary form, were unanimously adopted. As the new organisation largely owed its existence to the Yorkshire Philosophical Society —or at all events had been ushered into the world under the auspices of that old-established body—it seemed only a fitting compliment that the first chief officials of the British Association should be elected from amongst those who held similar offices in what might be called the parent society. Accordingly, Viscount Milton (afterwards Earl Fitzwilliam) was chosen to be the first in the long roll of illustrious men who have occupied the presidential chair. Dr. Buckland was chosen president-elect, with Dr. Brewster and Prof. Whewell as vice-presidents-elect, so that practically, while recognising their indebtedness to the Yorkshire Society, the first committee of the British Association took care to show their anxiety to secure for the future working of the association the most distinguished men of science available.

The presidential address has in the course of time come to be recognised as far and away the most important function connected with these annual assemblies, and it may be of interest here to remark that the character of these deliverances seems to have been suggested originally by Prof. Whewell. The first address—that of Viscount Milton—was delivered on Saturday evening, Oct. 2nd, 1831, and the contrast it presents to the addresses that we are accustomed to look for in these days is not a little striking, by reason of its brevity and owing to the fact that it was given by a nobleman who, with commendable modesty, declared that to the title of a man of science he unfortunately had no claim whatever. But, although not a scientist in the strict sense of the word, Lord Milton was a man possessing really extensive and intelligent acquaintance with many departments of scientific investigation. The first meeting of the "Parliament of Science" closed with a hearty acknowledgment on the part of the assembled visitors of the assistance which had been given by the residents of York and its vicinity in the promotion of its objects. This was admirably conveyed in a short speech by Sir Roderick Murchison, who declared that the city in which they were then gathered together would "ever be looked back to with gratitude as the cradle of the association." After the lapse of twelve months the association met again, this time at Oxford. Here it may be said that it first entered fairly upon its career, for at York the inaugural meeting had necessarily been devoted principally to settling the conditions under which the association should pursue its work. At the Oxford meeting, amongst those who took a leading part in the deliberations we find the names of Professor Buckland (the president), Professor Sedgwick, Sir David Brewster, Dr. Whewell, Michael Faraday, John Dalton, and Sir Roderick Murchison.

The association was now fairly launched, and, as might be expected, it had not long to wait before obtaining recognition as one of the institutions of our country. The detailed plan originally laid down for the conduct of its proceedings has since been followed, with but very slight deviation, down to the present day. The idea that the association should be a migratory body, and hold its meetings first in one town and then in another, instead of being centralised in some great city such as London, has proved of the greatest utility in maintaining its vitality; and although as an organisation it is now fast approaching the 60th year of its existence, it yet exhibits little or no sign of the weight of years. By moving about from place to place, and so interesting different communities in its work, not only has popular interest in the advances of science been intensified to a great degree, but the association itself as a body is constantly receiving fresh accessions of strength, and is consequently in the receipt of the financial support which is so essential to the effective carrying on of all institutions, whether they be philosophical, scientific, or political. The place of each meeting is apportioned by the general committee two years in advance, and as a rule there is a keen competition amongst the different towns in the kingdom to secure the distinction of being permitted to receive the association as the guests of their respective communities, but the number of towns that can afford the association the requisite guarantee is somewhat limited, and consequently it happens, for this and other reasons, that some places, such as York, Edinburgh, and Newcastle-upon-Tyne, have been twice, and even thrice, selected as the place of meeting.

We have already spoken of the presidential address as the principal function connected with these assemblies. But it is something more than that. It has come to be looked upon, not only in England, but throughout the world, as a sort of annual pronouncement by one of the highest living authorities of the advances that have been made in science generally up to that time, and more particularly in the special department of inquiry to which the President, for the time being, has devoted himself. Through the agency of the electric telegraph and the newspaper press, the outline, and often the text itself, is distributed far and wide within a few hours subsequent to its delivery, and for weeks afterwards it forms the staple topic of discussion in all scientific and literary circles. Next in importance to the President's address may be reckoned the addresses of the sectional presidents, and upon some of these it not unfrequently happens that very animated discussions ensue. Another thing which contributes towards investing the meeting with special public interest is the fact that often distinguished travellers who have returned home safely after years spent in exploring unknown regions are invited to attend and address the Association. In this way the late lamented Dr. Livingstone and his successors in the African exploration field, Commander Cameron and Mr. H. M. Stanley, have in their turn contributed papers or addresses recording their latest discoveries and achievements. It was hoped at one time that the Newcastle meeting would be memorable by reason of the presence of Mr. Stanley, but events have ordered otherwise.

The Association began its career under the most hopeful auspices, and encouraged by the countenance and support of the men who stood in the forefront of science half a century ago. It has, to say the least, not belied the sanguine expectations of its founders. More than anything else, perhaps, it has contributed to the unification of the several branches of science. Through its agency the patient and quiet workers in various fields of research have been put into possession of the results achieved by those who are labouring in other departments of investigation, and thus, through each contributing his quota to the common stock of knowledge, and the fruits of their industry being garnered into one common store, with every successive year the world has been made richer than it ever would have been if there had not existed such a valuable concentrative agency as the British Association. It has not only contributed by pecuniary and other aid to the vast extension of scientific study that the past half-century has witnessed, but it has powerfully helped to direct and systematise it. Moreover, it has broadened and liberalised scientific thought, and has at the same time maintained for scientific work in this country the dignity which properly belongs to it. When to this we add the fact that it has in no small degree been instrumental in enlarging our knowledge of the forces governing the universe, and that it has helped to remove wrong ideas and to bring truths of vital importance into the full light of day, it will be admitted that the Association has not lived in vain.

THE PREVIOUS MEETINGS IN NEWCASTLE.

1838.

The present is the third visit which the association has paid to our city, Newcastle having been amongst the earliest of the association's meeting places. So far back as the year 1838, in the first decade of the society's existence, it met in Newcastle for the first time. The selection of the capital of Tyneside was fully justified by the fact of the attendance being the largest recorded up to that date. The president for the year was the Duke of Northumberland, and the principal hall in which the representatives met was the Central Exchange. The inaugural assembly was held on the evening of August 20, 1838. Sir Roderick Murchison read the address of the general secretaries, which, in some measure, seems to have occupied the place now taken by the presidential deliverance. This secretarial address was intended rather, however, as a survey of the progress of the association and a forecast of its future work and prospects. The tone of it was throughout hopeful and enthusiastic. It reviewed the investigations that had been conducted with the assistance and under the authority of the association, and briefly alluded to the valuable papers that had been prepared by members, and included in its published transactions. Amongst those referred to in the report were Mr. Lubbock's observations on "Tidal Movements," Dr. Robinson's contributions to Astronomical Science, Professor Johnston's investigations concerning crystallization, and various reports drawn up by Professor Whewell.

The list of those present at the first Newcastle meeting included the names of many professors of science, eminent in their day, most of whom have long since gone over to the great majority. Sir David Brewster seems to have been one of the most active members of that time, especially in the department of mathematics and physics. Then there were Sir Charles Lyell, as representing geology ; Sir John Herschel, the great astronomer ; Captain (afterwards Admiral) Washington, the geographer ; Dr. Whewell, Mr. Babbage, Sir Wm. Jardine, Professor Wheatstone, Sir William Hamilton, Professor Johnston, the chemist, and Mr. G. B. Airy. Amongst the familiar names of local contributors to the sectional literature we come upon those of Mr. John Buddle, Professor Temple Chevallier, Mr. Nicholas Wood, Mr. Edward Backhouse, Mr. Hugh Lee Pattinson, Mr. Hawthorn. Dr. Maltby, the then Bishop of Durham, was also one of those who took a keen interest in the work of the association, and laboured to promote the success of the meeting.

The sectional meetings were held in different public rooms throughout the city. Mathematics and physics were accommodated in the Lit. and Phil. Society's premises; zoology and botany, chemistry and mineralogy, in the Moot Hall ; geology, geography, and mechanics, in the Music Hall ; statistics, in the Academy of Arts ; and medical science, in the Surgeons' Hall. As might be expected, having regard to the district in which the association was assembled, the sections devoted respectively to chemistry, mechanical science, and physics, proved the most attractive and the most fruitful in respect of local contributions. In the Mathematics and Physics Section, Sir David Brewster dealt with several subjects connected with the polarity of light ; Sir John Herschel contributed observations on Halley's comet ; while Sir William Hamilton spoke upon the propagation of light *in vacuo*. In the Chemical Section, it may be sufficient to notice, amongst a host of other papers, one contributed by the late Mr. Hugh Lee Pattinson, giving "An account of the discovery made by him of a process for the extraction of silver from lead." This was characterised as "one of the greatest discoveries of modern times." In the section devoted to geology, there appear to have been several papers of particular interest. Mr. John Buddle's observations on the Newcastle coal field constituted an essay of a highly valuable character, and having regard to the acknowledged authority of the author amongst mining engineers, we can well imagine that it would be received with respect. Mr. D. Milne contributed a paper on the coal field of North Northumberland ; and Mr. Nicholas Wood dealt with the red sandstone formations of the Tweed and Cumberland. It was in this section, too, that Mr. Griffiths read his paper on the geological structure of South Ireland, and exhibited the geological map of Ireland which had just then been prepared at the Ordnance Survey Office in Dublin. To the geographical department, Professor Von Baer, of St. Petersburg, contributed a couple of papers which were put before the meeting by Mr. W. R. Hamilton, the then president of the Royal Geographical Society. The first of these had reference to the soil of Siberia ; the second was a sketch of recent Russian expeditions to Novaïa Zemlaya. Now that a determined effort is being made by Captain Wiggins to open up regular over-sea trade with Siberia, it is curious to turn back to these papers in which, half a century ago, the subject of Siberian exploration was dealt with by a distinguished Russian geographer. The wild cattle of Chillingham Park had a paper specially devoted to them in the Zoological Section, by Mr. J. Hindmarsh, of Alnwick, who supplemented his own observations concerning the famous herd by a letter from the Earl of Tankerville, recounting what his lordship thought most noticeable in the habits and peculiarities of the Chillingham cattle. In the Mechanical Section, Mr. B. Green read a paper describing the timber viaducts then in progress of construction on the Newcastle and North Shields Railway, and exhibited plans and elevations of viaducts at Ouseburn and Willington Dene. Railway engineering was at that time, of course, almost in its infancy, and there were two or three suggestions of improved methods of laying down railway lines—improvements, as they were then considered, which would seem antiquated and obsolete notions to the engineer of to-day. Before taking leave of the Mechanical Section, it might be worth while noticing a paper read by Mr. Joseph Glynn, embodying the results of the survey made by him for the construction of a waterworks for Newcastle-on-Tyne. The works had then been completed at Elswick, and during the visit of the British Association the Water Company gave an invitation to the members to inspect them in operation. The last section—that devoted to statistics—had submitted to it about a score of papers, some of them of very slight and scarcely local importance. Perhaps the most noteworthy was Mr. Cargill's paper dealing with the educational statistics of Newcastle, in which it was stated that out of 16,000 children between the ages of 5 and 15, there were 48½ per cent. receiving no education at all. The total population of the city at that time was returned at 64,000.

The 1838 meeting was memorable for the circumstance that, whilst it was proceeding, the announcement was made that the Sirius had arrived in Liverpool after performing the then unprecedented feat of crossing and recrossing the Atlantic by steam. The news of this achievement, coming as a welcome and timely vindication of applied science, gave additional distinction to a brilliantly successful meeting.

1863.

A quarter of a century later the association assembled once again on Tyneside. The reception given to the members on the occasion of their first visit in 1838 had been so cordial in its character, the results so satisfactory to the association as a body, and the pleasure given to the inhabitants had been so considerable, that on the part both of the members and of their former hosts there had long been a disposition to renew acquaintance. There were other towns, however, whose claims could not be readily disposed of, and it was not until the 1862 meeting that the invitation for a return visit to Newcastle was accepted. In that year the association sat at Cambridge, and a deputation proceeded from Newcastle to press upon the Council the wish of the great Northern town to have the members amongst them once more as their guests. The deputation consisted of Mr. Isaac Lowthian Bell (then Mayor of Newcastle), Dr. Headlam, Sir William Armstrong, Sir W. C. Trevelyan, and Mr. R. C. Clapham. Upon a vote being taken, Newcastle was selected as the meeting place for the following year, securing 53 votes as against 36 recorded in favour of Bath, 7 for Nottingham, and 3 for Dundee. By the early part of 1863 a strong local committee had been constituted, and had set to work to make the necessary arrangements for the reception of the association. These having been duly completed, the annual meeting was opened on Wednesday, August 26. Just as the first Newcastle meeting had eclipsed the previous records in point of attendance, so did the second similarly surpass all that had been held during the subsequent 25 years. The number of members and associates exceeded 3,350, but it was not alone in the extent of attendance that the meeting was remarkable. It was the representative character of the gathering which gave it exceptional distinction, including as it did the names of nearly all the foremost men of their time in all the departments of scientific research and discovery. Some of these were men who had attended the 1838 meeting, and were even then known to fame ; others were men who had come to the front more recently ; whilst not a few of those who took a modest part in the proceedings and might then be regarded as comparatively obscure students, have since won their spurs and obtained world-wide recognition. A glance through the list of members who attended reveals such names as those of the venerable Professors Owen and Sedgwick ; Admiral Belcher, the great Arctic navigator ; Sir Charles Lyell, Sir Roderick Murchison, and Professor Phillips, first secretary of the association ; Professor Cayley, Mr. Crookes, the eminent chemist ; Sir John Lubbock, Professor Jowett, Professor Huxley, Captain Maury, celebrated for his researches respecting the law of storms ; General Sabine, President of the Royal Society ; Professor A. W. Williamson, Mr. Spottiswoode, Professor Rolleston, Professor Piazzi Smyth, and his brother, Professor Warington Smyth, and many others of similar calibre. Some of these were men who had passed the presidential chair, and some were destined subsequently to secure that coveted distinction.

Lord Armstrong (then Sir William Armstrong) had been chosen as president for the year, and his address was given in the Town Hall before an audience numbering at least 3,000 people. It proved to be just the sort of address that might have been expected from the founder of the Elswick Works. It was eminently thoughtful, practical, and free from the technology that has marred too many of the presidential addresses delivered in connexion with the association. In fact, it was rightly spoken of at the time as being the first address since Prince Albert's which had recognised the importance of intelligibility to the outside public. Sir William did not go far afield for his materials. He found them lying almost at his own door, in the coalfields of Northumberland and Durham, the district which had been the cradle of the railway system of the country. This important area sufficed as a basis on which was constructed a most elaborate and suggestive address. It is remembered to this day because of the views propounded by its distinguished author respecting the duration of our coalfields. Sir William argued that the phase of the earth's existence suitable for the formation of coal appeared to have passed away for ever. From this he passed on to enforce some important lessons respecting the wasteful expenditure of fuel, both for domestic and mechanical purposes, and he considered the possibilities to be looked for in the direction of developing other motive powers than that of steam. The address, it need scarcely be said, excited the liveliest interest, and the congratulatory remarks of Professor Willis in moving the customary vote of thanks expressed in no exaggerated form the enthusiastic appreciation of those who had the advantage of listening to it.

On the following day the various sections into which the association divides itself proceeded with the programme of business allotted to them. The sectional meetings of that year seem to have been invested with an amount of interest altogether unusual. There was scarcely one in which the discussions could be set down as dull and unprofitable. The most popular section, it almost goes without saying, was that devoted to geography, which met in the large Assembly Room under the presidency of Sir Roderick Murchison. Sir Roderick's inaugural address reviewed the recent explorations that had been made by Stuart, McKinlay, and Landborough in the interior of the Australian continent, and also the African discoveries of Speke and Grant, which had just then been communicated to the world. The Chemistry Section met in the Nelson Street Lecture Room, and Prof. Williamson, who presided, opened the proceedings with a really brilliant address. Subsequently Mr. J. C. Stevenson (the present member for South Shields) read a paper describing the history and progress of the chemical manufacturing trade of the Tyne. This was a valuable contribution in itself, and it may be referred to still with interest by all who are in any way concerned in the great changes which have since that day revolutionised this ancient industry. The Ven. Abbé Moigno was the most active figure of the Mathematical Section. In the department of Economic Science, the late Prof. Fawcett, then on the high road to fame, read a paper on the effect of the recent coal discoveries in California and Australia. Mr. Glaisher's account of his aerial voyages proved one of the most entertaining items in the programme of the Mathematical and Physical Science Section. Mention should also be made of a somewhat remarkable paper contributed to the Medical Science Section by Dr. Wilson, of Castle Eden, on the subject of "Northern Miners, their Habits and Diseases." The Monday of the second week was the busiest and most exciting day of the whole meeting in nearly all sections. In one there was to be found Sir Charles Lyell replying to the critics of his "Antiquity of Man;" in another, Captain Grant, who had just returned from Africa, recounted the incidents of his journeyings in the endeavour to discover the sources of the Nile; whilst in another Sir C. M. Palmer dealt with a subject of vital importance to many of those present, namely, the "Progress of Iron Shipbuilding on the Tyne, Wear, and Tees." A considerable amount of feeling was excited in the Geographical Section at two of its sittings, first by Dr. James Hunt's paper on the physical and mental character of the negro; and on another occasion by the appearance of Mr. William Craft, formerly a slave in America, who lectured on a visit he had made to the King of Dahomey. The circumstance which gave to these two occasions their special significance was the state of public feeling with respect to the American civil war then in progress. The final meeting of the association was held in the Town Hall, on Wednesday, September 2nd, when the thanks of the association to the local authorities were proposed by Sir Roderick Murchison and Professor Phillips.

Whilst the meeting had deserved the character of a memorable one by reason of the valuable papers contributed, and the eminence of those engaged in its deliberations, it must not be supposed that the recreative features usually associated with the visit of such a body were lost sight of. Excursions were made to all the places of interest within easy reach, and besides these there were receptions and other social functions for the entertainment of the city's scientific guests, including a banquet given by the members for Newcastle (Mr. S. Beaumont and Mr. T. Headlam) to the President and leading members of the association. There was also a balloon ascent by Messrs. Glaisher and Coxwell, which excited enormous interest; and Mr. Glaisher subsequently gave a lecture in the Town Hall before a very large audience, with Sir Wm. Armstrong in the chair. Taken altogether, the citizens of Newcastle had every reason to feel satisfied that they had done their duty as hosts; and there was abundant evidence that the visitors went away with a highly favourable impression of the community in which they had been temporarily located.

The Meeting.

FIRST DAY'S PROCEEDINGS.

WEDNESDAY, SEPTEMBER 11, 1889.

MEETING OF THE GENERAL COMMITTEE.

A meeting of the General Committee of the British Association was held yesterday at the Medical College, Bath Road, Newcastle, Sir Fred. Bramwell, President of the Association, in the chair. There was a good attendance, amongst those present being Professor W. H. Flower (President-Elect of the Association), Sir Douglas Galton (General Secretary), Mr. Aitchison (Secretary), Mr. A. G. Vernon Harcourt (General Secretary), Sir Erasmus Ommanney, &c.

The CHAIRMAN: I may remind you that this meeting is held for the purpose of receiving the report of the council and appointing sectional officers and a committee of recommendation. I will call upon the Secretary to read the minutes.

The GENERAL SECRETARY (Mr. Aitchison) read the minutes, which were confirmed and signed by the chairman.

Sir DOUGLAS GALTON read the annual report of the council for the year 1888-89, which was as follows :—

Since the meeting at Bath the following have been elected corresponding members of the association :—W. H. Dall, U.S. Geological Survey ; G. K. Gilbert, U.S. Geological Survey ; Dr. Max von Hantken, Budapest ; Horatia Hale, Ontario ; Prof. G. Stefanescu, Bucharest ; Wladimir Vernadsky, University of St. Petersburg.

The Council have nominated Sir Charles Mark Palmer, Bart., M.P., a vice-president of the meeting at Newcastle-upon-Tyne.

An invitation for the year 1891 will be presented from Cardiff.

The General Committee having granted a sum of £200 at their last meeting to the Marine Biological Association, thus making up the total sum given by the Association to £500, the Association became entitled to nominate a Governor of the Marine Biological Association, and the Council have nominated Professor Flower to the office.

It having been reported that the committee on the prehistoric inhabitants of the British Islands, appointed on the recommendation of the committee of Section H, had, through an oversight of the Sectional Secretary, not been reappointed, the committee have been informed that, if they will make a report to the section as if duly appointed, the Council are prepared to bring the matter before the Committee of Recommendations, with a view to the appointment of the committee and the publication of their report.

A request having been received from the honorary secretaries of the International Congress of Hygiene and Statistics, that the association would nominate two members to serve on the General Committee to be formed for organising the congress, the council have nominated Sir Frederick J. Bramwell and Sir H. E. Roscoe for that purpose.

The following resolution was referred by the General Committee to the council for consideration and action if desirable :—

> That the council be recommended to consider what measures, if any, it might be desirable to take with respect to the apparatus from time to time purchased by funds voted by the association.

The council, after consideration of the question, are of opinion that the attention of the chairmen and members of committees should be specially directed to the existing rules, viz. :—

> Members and committees who may be entrusted with sums of money for collecting specimens of Natural History, are requested to reserve the specimens so obtained for distribution by authority of the association.
>
> All instruments, papers, drawings, and other property of the association are to be deposited in the office, 22, Albemarle Street, London, when not employed in carrying on scientific inquiries for the association.

and that they should be requested in each year, prior to the dissolution of the committee, to furnish a list of any apparatus which may have been purchased out of the grant made by the Association, distinguishing the apparatus which in their opinion may continue to be useful for the research in question or for other scientific purposes.

The following resolution was referred by the General Committee to the council for consideration and action if desirable :—

> "That the Council of the Association be requested to urge upon the Corporation of Bath the desirability of laying bare a further portion of the unique Roman Baths at that city, with a view to their permanent preservation ; and that the part already laid bare should be protected from the weather."

The council resolved that the views set forth in the resolution should be embodied in a letter and forwarded to the Corporation of Bath, together with a cheque for the sum of £100, which the General Committee had resolved to place at the disposal of the Baths Committee of the Bath Corporation for the prosecution of their investigations.

The following resolution was referred by the General Committee to the council for consideration and action if desirable :—

> "That the council be requested to memorialise her Majesty's Government in favour of establishing a permanent census sub-department, and taking the census of the United Kingdom every five years."

The council are of opinion that it is inexpedient to take action in the matter.

A request was made on behalf of the committee of Section H, that the council would communicate to the Canadian Government the fact that the association had granted £150 to a committee for investigating the North-Western tribes of the Dominion, and would express the desirability of this grant being supplemented to an equal amount by the Canadian Government. A letter was written to the Canadian Government in accordance with the above request, asking them to contribute a similar amount to that granted by the association, and a letter from the secretary of the High Commissioner for Canada was subsequently received transmitting a copy of an order in council recommending that the application should be granted.

Early in the present year, Mr. Atchison, the secretary, informed the council that his health had materially suffered during the past winter ; that his medical advisers stated that it was imperative for him to spend the next three winters in a warm climate ; and that, under those circumstances, he did not propose to offer himself for re-election at the next meeting of the association. The council received this announcement with great regret ; but, as there appeared to be no prospect of Mr. Atchison being able to avoid this absence from England, they took into consideration the duties of the office which he had held and the appointment of a successor.

The Council resolved that it is desirable that the officer to be appointed in Mr. Atchison's place, to act under the direction of the General Secretaries, should be named, as formerly, Assistant General Secretary, that the salary should be fixed at £300 a year, and that the expense of journeys undertaken on behalf of the Association should be repaid.

The Council have nominated Mr. Hubert Llewellyn Smith for the appointment.

The report of the Corresponding Societies Committee is herewith submitted to the General Committee.

The Corresponding Societies Committee, consisting of Mr. Francis Galton (chairman), Professor R. Meldola (secretary), Professor A. W. Williamson, Sir Douglas Galton, Professor Boyd Dawkins, Sir Rawson Rawson, Dr. J. G. Garson, Dr. J. Evans, Mr. J. Hopkinson, Mr. W. Witaker, Mr. G. J. Symons, General Pitt-Rivers, Mr. W. Topley, and Professor T. G. Bonney, is hereby nominated for reappointment by the General Committee.

The council nominate Mr. Francis Galton, F.R.S., chairman ; Professor T. G. Bonney, F.R.S., vice-chairman ; and Professor G. A. Lebour, F.G.S., secretary, to the Conference of Delegates of Corresponding Societies, to be held during the Newcastle-upon-Tyne meeting.

In accordance with the regulations the five retiring members of the council will be :—Captain W. de W. Abney, W. H. Barlow, Esq., Lieutenant-Colonel H. H. Godwin-Austen, Professor O. Henrici, and W. T. Thiselton-Dyer, Esq.

The council recommend the re-election of the other ordinary members of council, with the addition of the gentlemen whose names are distinguished by an asterisk in the following list :—*Professor W. E. Ayrton, F.R.S., *B. Baker, Esq., M. Inst. C.E., Sir R. S. Ball, F.R.S., W. T. Blanford, Esq., F.R.S., W. Crookes, Esq., F.R.S., Professor G. H. Darwin, F.R.S., Sir James Douglass, F.R.S., *Dr. J. Evans, F.R.S., *Professor G. F. Fitzgerald, F.R.S., Dr. A. Gamgee, F.R.S., Dr. A. Geikie, F.R-S., Professor J. W. Judd, F.R.S., *Professor E. Ray Lankester, F.R.S., Professor Liveing, F.R.S., J. B. Martin, Esq., F.S.S., Professor H. McLeod, F.R.S., Admiral Sir E. Ommanney, C.B., F.R.S., W. H, Preece, Esq., F.R.S., Professor W. C. Roberts-Austen, F.R.S., Professor Rücker, F.R.S., Professor Schuster, F.R.S., Professor H. Sidgwick, M.A., Professor Schäfer, F.R.S., Professor T. E. Thorpe, F.R.S., Dr. H. Woodward, F.R.S.

Sir DOUGLAS GALTON then moved that the report be adopted.

Mr. W. WHITAKER : May I ask if the adoption of the report implies the carrying of everything in it at once, or whether any of the matters in it are reserved for definite consideration one by one?

Sir DOUGLAS GALTON : The matters that will come up at the next meeting are the appointment of the council and the appointment of the officers. Those take place at the committee meeting on Monday.

Mr. WHITAKER : That is all I want.

The report was then adopted.

The PRESIDENT : I now call upon Sir Erasmus Ommanney to read the treasurer's report. The treasurer is not able to be present, and Sir Erasmus Ommanney has kindly undertaken to act as treasurer for the Newcastle meeting.

Admiral Sir ERASMUS OMMANNEY then read the treasurer's report as follows :—

Dr.	£	s.	d.
Balance of account rendered at Bath Meeting	239	10	5
By life compositions	450	0	0
,, New annual members	244	0	0
,, Annual subscriptions	706	0	0
,, Associate tickets at Bath Meeting	621	0	0
,, Ladies' tickets at Bath Meeting	509	0	0
,, Sale of publications	47	18	6
,, Sale of reports, by Mr Murray, 1887-1888	103	0	0
,, Sale of reports, by Mr Murray, 1888-1389	108	16	0
,, Rent received from Mathematical Society for year ended 29th September, 1888	12	15	0
,, Interest on Exchequer bills	10	19	5
,, Dividends on Consols	243	9	1
,, Dividends on India 3 per Cents.	105	6	0
,, Return of grants paid to Mr S. Bourne for "Precious Metals in Use" and "Monetary Standards"	30	0	0
,, Unexpended balance of grant for Ceylon Botanical Station	7	6	5
,, Unexpended balance of grant for "Nomenclature for Fundamental Units of Mechanics"	7	2	5
	£3,451	3	3

Cr.	£	s.	d.
To expenses of Bath Meeting, including printing and advertising, &c., also expenses of lecture by Prof. Ayrton	339	17	4
,, Salaries, one year, 1888-89	525	0	0
,, Rent of office at 22, Albemarle Street, 1888-89	117	0	0

PAYMENT OF GRANTS.

	£	s.	d.	£	s.	d.
Volcanic phenomena of Japan	25	0	0			
Geology and geography of Atlas range	100	0	0			
Observations on surface water temperature	30	0	0			
Bath "Baths Committtee" for further researches	100	0	0			
Flora of China	25	0	0			
Natural history of Friendly Islands	100	0	0			
Physiology of lymphatic system	25	0	0			
Volcanic phenomena of Vesuvius	20	0	0			
Characteristics of Nomad tribes of Asia Minor	30	0	0			
Fossil phyllopoda of Palæozoic rocks	20	0	0			
Investigation into North-Western tribes of Canada	150	0	0			
West Indian explorations..................	100	0	0			
Corresponding societies	20	0	0			
Experiments with a tow net	5	16	3			
Geological record	80	0	0			
Marine Biological Association	200	0	0			
Naples zoological station	100	0	0			
Higher Eocene beds of Isle of Wight	15	0	0			
Ben Nevis observatory	50	0	0			
Methods of teaching chemistry	10	0	0			
Action of light on hydracids of the halogen in presence of oxygen	10	0	0			
Electrical standards	75	0	0			
Action of waves and currents in estuaries, by means of working models............	100	0	0			
Electrolysis	20	0	0			
Silent discharge of electricity on oxygen ..	6	4	8			
				1,417	0	11
By balance at Bank of England, Western Branch......				1,052	5	0
				£3,451	3	3

ALEXANDER WM. WILLIAMSON, Treasurer.

Investments Account: September, 1888, to September, 1889.

DEBIT.	£	s.	d.	CREDIT.	£	s.	d.
New Consols........	8,500	0	0	New Consols........	8,500	0	0
India 3 per Cents. ..	3,600	0	0	India 3 per Cents. ..	3,600	0	0
Exchequer Bills	500	0	0	Exchequer Bills	500	0	0
Cash	239	10	5	Cash	1,052	5	0
Excess of receipts over expenditure..	812	14	7				
Total	£13,652	5	0	Total	£13,652	5	0

Sir ERAMUS OMMANNEY moved that the accounts rendered by the general treasurer be received and adopted.

Sir DOUGLAS GALTON seconded, and the motion was carried.

The CHAIRMAN called upon the secretary to read the list of sectional officers proposed, which had appeared in the official programmes.

The CHAIRMAN proposed that the gentlemen named be elected to the positions named.

Sir ERASMUS OMMANNEY seconded, and the motion was carried.

It was agreed to make the following additions to the different sections :—

Section A.—Vice-presidents, Lord Rayleigh, Lord Armstrong, Sir Wm. Thomson, Professor Cayley, Professor Fitzgerald, and Mr James Glaisher.

Section C.—Vice-president, Chevalier Max Von Hantken, Pierre de Tchihatcheff, and Mr John Marley.

Section D.—Vice-presidents, O. Salvin, Professor G. S. Brady, and Canon Norman.

Section E.—Vice-president, Professor Batalha Reis.

Section F.—Vice-presidents, Mr F. G. W. Hastings, M.P., and Professor Sedgwick.

Section G.—Vice-presidents, Lord Armstrong, Sir Fred. J. Bramwell, Sir Benjamin Browne, and Professor A. B. W. Kennedy.

Section H.—Vice-presidents, Mr Francis Galton, Gen. Pitt Rivers, and secretary, Mr Robert Howden.

Sir DOUGLAS GALTON proposed that the officers of the different sections constitute a committee of recommendation.

Mr. VERNON HARCOURT seconded, and the motion was agreed to.

This was all the business, and the committee adjourned.

DISTINGUISHED VISITORS.

The following is a list of the more prominent visitors and members of the British Association attending the Newcastle Meeting, with the names of their hosts :—

Abel, Sir Frederick Augustus, C B, D C L, F R S, F C S, President of the Government Committee on Explosives, Royal Arsenal, Woolwich ; Captain Noble, Jesmond Dene House

Abercromby, The Hon. Ralph, F R Met. Soc., 21, Chapel Street, Belgrave Square, London, S.W.

Abney, Captain W. de W., R E, C B, F R S, F R S E, F R A S, F C S, Willeslie House, Wetherby Road, South Kensington, London, S.W.; Captain Noble, Jesmond Dene House

Acland, Sir Henry W. D., K C B, M A, M D, LL D, F R S, F R G S, Broad Street, Oxford ; Bishop of Newcastle, Benwell Tower

Adams, Professor William Grylls, M A, D Sc., F R S, F G S, F C P S, 43, Notting Hill Square, London, W.; Mr. Lovebond, 6, Tankerville Terrace

Anderson, Professor R. J., M D, Queen's College, Galway, and Beach Hill, Newry, Ireland

Anderson, William, M Inst. C E, Lesney House, Erith, Kent ; Hon. C. A. Parsons, Elvaston House

Anelay, Miss M. Mabel, Girton College, Cambridge; 6, St. Mary's Place

Armstrong, The Right Hon. Lord, C B, LL D, D C L, F R S, Cragside ; Jesmond Dene, Newcastle-on-Tyne

Armstrong, Sir Alexander, K C B, M D, LL D, F R S, F R G S, The Albany, London, W.

Armstrong, George Frederick, M A, F R S E, F G S, Regius Professor of Engineering in the University of Edinburgh, The University, Edinburgh

Atchison, Arthur T., M A, *Secretary*, 22, Albermarle Street, London, W.

Baker, Benjamin, M Inst C E, 2, Queen Square Place, Westminster, S.W. ; 17, Portland Place

Barrett, W. F., F R S E, M R I A, Professor of Physics in the Royal College of Science, Dublin ; R. S. Donkin, M.P., Campville, North Shields

Becker, Miss Lydia E., 155, Shrewsbury Street, Whalley Range, Manchester

Beddard, Frank E., M A, F Z S, Prosector to the Zoological Society of London, Society's Gardens, Regent's Park, London, S.W. ; The Secretarium.

Bell, Sir Lowthian, Bart, F R S, F C S, M Inst C E, Rounton Grange, Northallerton ; J. W. Pease, Benwell

Blake, C. Carter, D Sc, 4, Charlton Street, Fitzroy Square, London, W.

Blyth, James, M A, F R S E, Professor of Natural Philosophy in Anderson's College, Glasgow : 19, Portland Terrace

Bottomley, James Thomson, M A, F R S, F R S E, F C S, 13, University Gardens, Glasgow ; Dr. Merz, The Quarries

Bower, F. O., F L S, Professor of Botany in the University of Glasgow ; The College, Durham

Brady, George S., M D, F R S, F L S, Professor of Natural History in the Durham College of Science, Newcastle-on-Tyne, 2, Mowbray Villas, Sunderland

Bramwell, Sir Frederick J., Bart., D C L, F R S, M Inst C E, 5, Great George Street, London, S.W. ; Captain Noble, Jesmond Dene House

Brown, Prof J. Campbell, D Sc, F C S, University College, Liverpool

Browne, Sir J. Crichton, M D, LL D, F R S L and E, 7, Cumberland Terrace, Regent's Park, London, N.W

Buxton, Sir Thomas Fowell, Bart, F R G S, Warlies, Waltham Abbey, Essex ; R. G. Hoare, Jesmond Park

Campbell, Sir George, K C S I, M P, D C L, F R G S, F S S, Southwell House, Southwell Gardens, South Kensington, London

Carlisle, The Right Rev. Harvey Goodwin, D D, D C L, Lord Bishop of, Carlisle ; Bishop of Newcastle, Benwell Tower

Cayley, Arthur, M A, D C L, LL D, F R S, V P R A S, Sadlerian Professor of Pure Mathematics in the University of Cambridge, Garden House, Cambridge ; Lord Armstrong, Jesmond Dene

Clowes, Frank, D Sc, F C S, Professor of Chemistry in University College, Nottingham, University College, Nottingham ; Prof. Garnett, 4, Sydenham Terrace.

Copeland, Ralph, Astronomer Royal for Scotland, Edinburgh ; Rev. T. J. Storey, Vicarage, Blackhill

Crosskey, Rev. H. W., LL D, F G S, 117, Gough Road, Birmingham ; E. Fothergill, 10, Eldon Square

Cunningham, D. J., M D, Professor of Anatomy in Trinity College, Dublin ; J. Robertson Crease, 2, Ogle Street, South Shields

Cunningham, Rev. William, B D, D Sc, Trinity College, Cambridge ; The Secretarium

Dallinger, Rev. W. H., LL D, F R S, F L S, Ingleside, Newstead Road, Lee, London, S.E. ; U. K. Ritson, 1, Jesmond Gardens

Dawkins, W. Boyd, M A, F R S, F G S, F S A, Professor of Geology and Palæontology in the Victoria University, Owens College, Manchester ; Three Tons Hotel, Durham

Denny, Alfred, F L S, Professor of Biology, Firth College, Sheffield

Dixon, Harold B., M A, F R S, F C S, Professor of Chemistry in the Owens College, Manchester, Birch Hall, Rusholme, Manchester ; C. J. Richardson, Mardale Parade, Gateshead

Douglass, Sir James N., F R S, M Inst. C E, Trinity House, London, E.C.; Central Station Hotel

Dunstan, Wyndham, R., M A, F C S, Professor of Chemistry to the Pharmaceutical Society of Great Britain, 17, Bloomsbury Square, London, W.C.; The College, Durham

Edgeworth, F. Y., M A, F S S, Professor of Political Economy in King's College, London; Savile Club, 107, Piccadilly, London, W.; Lord Armstrong, Jesmond Dene

Evans, John, D C L, LL D, Treas. R S, F S A, F L S, F G S, Nash Mills, Hemel Hempstead

Everett, J. D., M A, D C L, F R S, L & E, Professor of Natural Philosophy in Queen's College, Belfast, 5, Prince's Gardens, Belfast

Ewart, J. Cossar, M D, Professor of Natural History in the University of Edinburgh

Ewing, James Alfred, B Sc, F R S, L & E, Professor of Engineering in University College, Dundee; A. B. Davidson, 5, Swinburne Place, Westgate Road

Faraday, F. J., F L S, F S S, College Chambers, 17, Brazenose Street, Manchester; County Hotel

Ferguson, John, M A, Professor of Chemistry in the University of Glasgow

Fitzgerald, George Francis, M A, F R S, Professor of Natural and Experimental Philosophy, Trinity College, Dublin

Flower, William Henry, C B, LL D, F R S, F L S, F G S, F R C S, Director of the Natural History Departments, British Museum, South Kensington, London, President, 26, Stanhope Gardens, London, S.W.; Lord Armstrong, Jesmond Dene

Foster, George Carey, B A, F R S, F C S, Professor of Physics in University College, London, 18, Daleham Gardens, Hampstead, London, N.W.

Fox, Howard, United States Consul, Falmouth; J. W. Pease, Pendower

Fream, W., LL D, B Sc, F L S, F G S, F S S, Professor of Natural History in the College of Agriculture, Downton, Salisbury

Gairdner, Professor W. T., M D, 225, St. Vincent Street, Glasgow

Galton, Sir Douglas, K C B, D C L, LL D, F R S, F L S, F G S, F R G S, General Secretary, 12, Chester Street, Grosvenor Place, London, S.W.; Lord Armstrong, Jesmond Dene

Galton, Francis, M A, F R S, F G S, F R G S, 42, Rutland Gate, Knightsbridge, London, S.W.; Mrs Spence Watson, Bensham Grove, Gateshead

Gamgee, John, 6. Lingfield Road, Wimbledon, Surrey; Mrs Robley, 11, Lovaine Terrace

Geikie, Archibald, LL D, F R S L and E, F G S, Director-General of the Geological Survey of the United Kingdom, Geological Survey Office, Jermyn Street, London, S.W.; Mrs Fothergill, Eldon Square.

Geikie, James, LL D, F R S L and E, F G S, Murchison Professor of Geology and Mineralogy in the University of Edinburgh, 51, Merchiston Avenue, Edinburgh; Canon Lloyd.

Gill, His Honour the Deemster, Douglas, Isle of Man; 21, Lovaine Place.

Gladstone, John Hall, Ph D, F R S, F C S, 17, Pembridge Square, London, W.; County Hotel.

Glaisher, James, F R S, F R A S, I, Dartmouth Place, Blackheath, London, S.E.

Gouraud, Colonel, Little Menlo, Norwood, Surrey.

Green, Professor A. H., M A, F R S, F G S, 137, Woodstock Road, Oxford; F. Marshall, Grosvenor Place.

Green, Professor Jos. R,, M A, B Sc, Trinity College, Cambridge; 1, Lovaine Terrace.

Greenhill, A. G., M A, F R S, Professor of Mathematics at the Royal Artillery Institution, Woolwich, 3, Staple Inn London, W.C.

Greenwood, Professor W. H., M Inst C E, Firth College, Sheffield.

Haddon, Alfred Cort, B A, F Z S, Professor of Zoology in the Royal College of Science, Dublin; 17, Ridley Place

Harcourt, A. G. Vernon, M A, LL D, F R S, F C S, General Secretary. Cowley Grange, Oxford; W. Cochrane, Oakfield House, Gosforth

Harkness, William, F C S, Laboratory, Somerset House, London, W.C.

Hartley, Walter Noel, F R S L and E, F C S, Professor of Chemistry in the Royal College of Science, Dublin; Dr Adam Wilson, Osborne House

Haughton, Rev. Samuel, M A, M D, D C L, LL D, F R S, M R I A, F G S, Senior Fellow of Trinity College, Dublin, Trinity College, Dublin; Dr J. Murphy, Holly House, Sunderland

Hawksley, Thomas, M Inst C E, F R S, F G S, 30, Great George Street, London, S.W.

Hay, Admiral the Right Hon. Sir John C. D., Bart, K C B, D C L, F R S, 108, St. George Square, London S.W.; Henry Milvain, North Elswick Hall

Heawood, Percy Y., Lecturer in Mathematics at Durham University, 41, Old Elvet, Durham

Hennessy, Henry G., F R S, M R I A, Professor of Applied Mathematics and Mechanics in the Royal College of Science for Ireland, Brookvale, Donnybrook, Co. Dublin

Herdman, William A., D Sc, Professor of Natural History in University College, Liverpool

Herschell, Colonel John, R E, F R S, F R A S, Observatory House, Slough, Bucks

Hicks, Professor W. M., M A, F R S, Principal of Firth College, Sheffield, Firth College, Sheffield; Professor Garnett, 4, Sydenham Terrace

Hodgkinson, W. R. Eaton, Ph D, F R S E, Professor of Chemistry and Physics in the Royal Artillery College, Woolwich, 75, Vanbrugh Park, Blackheath, London, S.E.

Howell, Henry H., F G S, Director of the Geological Survey of Scotland, Geological Survey Office, Victoria Street, Edinburgh, F. Springman

Howes, Professor, G. B., F L S, Science Schools, South Kensington, London, S.W.

Hull, Edward, M A, LL D, F R S, F G S, Director of the Geological Survey of Ireland, and Professor of Geology in the Royal College of Science, 14, Hume Street, Dublin

Jones, J. Viriamu, M A, B Sc, Principal of the University College of South Wales and Monmouthshire, Cardiff; Hill Motum, Helensville, Grainger Park Road

Judd, John Wesley, F R S, F G S, Professor of Geology in the Royal School of Mines, Hurstleigh, Kew; Bishop of Newcastle

Keltie, J. Scott, Librarian R G S., I, Savile Row, London, W.; The Secretarium

Kennedy, Alexander B. W., F R S, M Inst C E, Professor of Engineering in University College, London; Sir B. C. Browne, West Acres, Newcastle

Knott, Cargill G., D Sc, F R S E, Tokyo, Japan

Lambert, Rev Brooke, LL B, The Vicarage, Greenwich, Kent, S.E.; W. Cochrane, Oatfield House, Gosforth

Lankester, E. Ray, M A, LL D, F R S, Professor of Comparative Anatomy and Zoology in University College, London, 45, Grove End Road, London, N.W.; Earl of Scarborough, Lumley Castle, Chester-le-Street

Liveing, G. D., M A, F R S, F C S, Professor of Chemistry in the University of Cambridge, Newnham, Cambridge; Mrs Pyman, Kelso House

Lockyer, J. Norman, F R S, F R A S, Science Schools, South Kensington, London, S.W.; Capt. Noble, Jesmond Dene House

Lodge, Oliver J., D Sc, LL D, F R S, Professor of Physics in University College, Liverpool, 21, Waverley Road, Sefton Park, Liverpool; H. C. Jepps, Normanhurst, Sunderland

Lubbock, Sir John, Bart, M P, D C L, LL D, F R S, F L S, F G S, Down, Farnborough, Kent; R. G. Hoare, Jesmond Park

Lupton, Arnold, M Inst C E, F G S, Professor of Mining Engineering in Yorkshire College, 6, De Grey Road, Leeds

Macadam, Stevenson, Ph D, F R S E, F C S, Lecturer on Chemistry, Surgeons' Hall, Edinburgh, and Brighton House, Portobello, by Edinburgh

McIntosh, W. C., M D, LL D, F R S L and E, F L S, Professor of Natural History in the University of St Andrews, 2, Abbotsford Crescent, St Andrew's, N B; Professor Brady, Sunderland

McLaren, the Right Hon. Lord, F R S E, 46, Moray Place, Edinburgh

McLeod, Herbert, F R S, F C S, Professor of Chemistry in the Royal Indian Civil Engineering College, Cooper's Hill, Staines

Marshall, A. Milnes, M A, M D, D Sc, F R S, Professor of Zoology in Owens College, Manchester; R. Mawson, Sydenham Terrace

Miall, Louis C., F G S, Professor of Biology in Yorkshire College, Leeds, 3, Montpellier Terrace, Leeds; Dr. Brady, Mowbray Villas, Sunderland

Milne, John, F R S, F G S, Professor of Geology in the Imperial College of Engineering, Tokio, Japan, Birdhirst Rise, South Croydon, Surrey

Morley, Henry Forster, M A, D Sc, F C S, University Hall, Gordon Square, London, W.C.; The Secretarium

Moloney, C. A., Governor of Lagos

Neale, E. Vansittart, 14, City Buildings, Corporation Street, Manchester

Newton, Alfred, M A, F R S, F L S, Professor of Zoology in the University of Cambridge, Magdalene College, Cambridge; Professor Philipson, Eldon Square

Oliver, Daniel, F R S, F L S, Professor of Botany in University College, London, Royal Gardens, Kew, Surrey

Ommanney, Admiral Sir Erasmus, C B, F R S, F R A S, F R G S, 29, Connaught Square, Hyde Park, London, W.; Lord Armstrong, Jesmond Dene

Palgrave, R. H. Inglis, F R S, F S S, Belton, Great Yarmouth

Pearce, Rev. Professor, D C L, Durham

Pengelly, William, F R S, F G S, Lamorna, Torquay; 18, Wentworth Place

Perry, John, M E, D Sc, F R S, Professor of Engineering and Applied Mathematics in the Technical College, Finsbury, 10, Penywern Road, South Kensington, London, S.W.

Pitt-Rivers, Lieut.-General A. H. L., D C L, F R S, F G S, F S A, 4, Grosvenor Gardens, London, S.W.; Royal Turk's Head Hotel

Playfair, Lieut.-Colonel Sir R. L., K C M G, H M Consul, Algeria

Preece, William Henry, F R S, M Inst C E, Gothic Lodge, Wimbledon Common, Surrey; Hon C. A. Parsons, Elvaston Hall

Rae, John, M D, LL D, F R G S, 4, Addison Gardens, Kensington, London, W; Mr Havelock, 70, Osborne Road

Rayleigh, the Right Hon Lord, M A, D C L, LL D, Sec R S, F R A S, F R G S, Terling Place, Witham, Essex; Earl of Scarborough, Lumley Castle

Reynolds, James Emerson, M D, F R S, F C S, M R I A, Professor of Chemistry in the University of Dublin, The Laboratory, Trinity College, Dublin

Reynolds, Osborne, M A, LL D, F R S, M Inst C E, Professor of Engineering in Owens College, Manchester, Fallowfield, Manchester

Rigg, Edward, M A, Royal Mint, London, E; The Secretarium

Roberts-Austen, W. Chandler, F R S, F C S, Chemist to the Royal Mint, and Professor of Metallurgy in the Royal School of Mines, Royal Mint, London, E. ; 6, Percy Terrace
Romanes, George John, M A, LL D, F R S, F L S, 18, Cornwall Terrace, Regent's Park, London, N.W. ; Professor Oliver, 12, Eldon Square
Rosse, the Right Hon the Earl of, B A, D C L, LL D, F R S, F R A S, M R I A, Birr Castle, Parsonstown, Ireland ; Hon C. A. Parsons, Elvaston Hall
Rucker, A. W., M A, F R S, Professor of Physics in the Royal School of Mines, Errington, Clapham Park, London, S.W. ; F. Newall, Birtley
Russell, William J., Ph D, F R S, F C S, Lecturer on Chemistry in St Bartholomew's Medical College, 34, Upper Hamilton Terrace, St John's Wood, London, N. W.
Schuster, Arthur, Ph D, F R S, F R A S, Professor of Physics in the Owens College, Brighton Grove, Rusholme, Manchester ; Professor Garnett, 4, Sydenham Terrace
Scott, Arthur William, M A, Professor of Mathematics and Natural Science in St. David's College, Lampeter
Scott, Professor A. W., M A, St. David's College, Lampeter, South Wales ; Mrs. Turner. 20, Bolton Terrace
Seebohm, Henry, F L S, F Z S, 6, Tenterden Street, Hanover Square, London, W. : Canon Tristram, Durham
Senior, Alfred, M D, PhD, F C S, Thornfield, Harold Road, London, S.E.
Smithells, Arthur, B Sc, Professor of Chemistry in the Yorkshire College, Leeds ; A. Coate, The Minories
Snape, H. Lloyd, DSc, PhD, F I C, Professor of Chemistry in University College, Aberystwith ; Mrs. Telfour, 18, Wharncliffe Street
Stopes, Mrs Kenwyn, Cintra Park, Upper Norwood, S.E. ; 9, Picton Place
Swan, Joseph Wilson, M A, Lauriston, Bromley, Kent ; J. Pattinson, Shipcote House, Gateshead
Tait, Lawson, F R C S, The Crescent, Birmingham
Taylor, Rev. Canon Isaac, D D, Settrington Rectory, York
Thompson, Claude M., M A, Professor of Chemistry in University College, Cardiff; Spence Watson, Bensham Grove, Gateshead
Thompson, D'Arcy W., B A, Professor of Physiology in University College, Dundee
Thompson, Silvanus Phillips, B A, D Sc, F R A S, Professor of Physics in the City and Guilds of London Institute, Finsbury Technical Institute, E.C. ; W. H. Holmes, Wellburn, Jesmond
Thomson, Professor James, M A, LL D, D Sc, F R S L and E, 2, Florentine Gardens, Hillhead Street, Glasgow
Thomson, Joseph, Thornhill, Dumfriesthire
Thomson, Sir William, M A, LL D, D C L, F R S L and E, F R A S, Professor of Natural Philosophy in the University of Glasgow ; Captain Noble, Jesmond Dene House
Thomson, Lady, the University, Glasgow ; Captain Noble, Jesmond Dene House
Thuillier, General Sir H. E. L., R A, C S I, F R S, F R G S, Tudor House, Richmond Green, Surrey ; Mrs Davidson, 18, Ellison Place
Topley, William, F R S, F G S, A I C E, Geological Survey Office, Jermyn Street, London, S.W. ; E. A. Hedley, 8, Osborne Villas
Traquair, Ramsay H., M D, F R S, F G S, Keeper of the Natural History Collections, Museum of Science and Art, Edinburgh ; 41, Eldon Street
Tristram, Rev. Henry Baker, D D, LL D, F R S, F L S, Canon of Durham, The College, Durham
Turner, Sir William, M B, LL D, F R S L and E, Professor of Anatomy in the University of Edinburgh, 6, Eton Terrace, Edinburgh ; Dr Page, 1, Saville Place
Vines, Sydney Howard, M A, D Sc, F R S, F L S, Professor of Botany in the University of Oxford, Fairacres, Oxford
Ward, H. Marshall, M A, F R S, F L S, Professor of Botany in the Royal Indian Civil Engineering College, Cooper's Hill, Egham ; The Secretarium
Webber, Major-General, C.E., C B, 17, Egerton Gardens, London, S.W. ; J. W. Pease, Pendower
White, A. Silva, Secretary to the Royal Scottish Geographical Society, Edinburgh ; The Secretarium
Williamson, Professor C., LL D, F R S, 4, Egerton Road, Fallowfield, Manchester ; Rev. Canon Pennefather, Eldon House, Jesmond
Windle, Professor Bertram C. A., Queen's College, Birmingham ; 50, Lovaine Place
Winton, Colonel Sir F. de, K C M G, F R G S, 24, Tavistock Road, Westbourne Park, London, W. ; Mrs Harrison, Whitburn
Woodward, Henry, LL D, F R S, F G S, Keeper of the Department of Geology, British Museum (Natural History), Cromwell Road, London, S.W. ; Rev. A. Gooderham, 83, Jesmond Road
Woodward, Horace B., F G S, Geological Museum, Jermyn Street, London, S.W. ; Sidney Reid, 12, Claremont Place.

THE PRESIDENT.

A BIOGRAPHICAL SKETCH.

The president is Professor Flower, the eminent naturalist, director of the Natural History Museum, South Kensington, and president of the Zoological Society. He is the second son of the late Mr. Edward Fordham Flower, J.P., of The Hill, Stratford-upon-Avon, and of Celina, eldest daughter of Mr. John Greaves, of Radford Semele, Warwickshire, and was born at Stratford-upon-Avon, November 30, 1831. He was educated at private schools, and at University College, London. An early taste for natural history pursuits, especially for collecting and dissecting animals, led him to select the profession of medicine, and, through the study of physiology, he has become one of the most distinguished anthropologists and biologists of the time. In 1849 he matriculated at the University of London, with honours in zoology, and, in the same year, entered the medical classes at University College, and became a pupil at the Middlesex Hospital. During his studentship at the former institution, he gained the gold medal in Dr. Sharpey's class of physiology, with the silver medal in zoology, and passed the first M.B. at the London University in 1851, coming out in the first division. He became a Member of the Royal College of Surgeons of England on March 27, 1854 ; and, a few weeks afterwards, being desirous of improving his knowledge of surgery, he joined the medical department of the army, with a view to serving in the campaign about to

PROFESSOR W. H. FLOWER,
C.B., LL.D., F.R.S., &c.,
President of the Newcastle-on-Tyne Meeting, 1889.
(Engraved from a photograph, by kind permission of Messrs Elliot and Fry, 55, Baker Street, W.)

be commenced against the Russians. After spending a few months with the depôt battalion at Templemore, in Ireland, he was gazetted as assistant-surgeon to the 63rd Regiment, and embarked at Cork in July for Constantinople. The regiment joined the main army at Varna, and took part in the expedition to the Crimea, in which it suffered very severely from exposure to the severity of the climate during the early months of the campaign. For ten weeks officers and men alike did not take off their clothes, night or day, and for the first three weeks they slept every night in the open air. The influences which caused the death of nearly half the strength of the regiment in four months affected Mr. Flower's health; he was invalided to England, and soon after received from the hands of the Queen the war medal, with clasps, for Alma, Inkerman, Balaclava, and Sebastopol.

An opportunity having presented itself for joining the staff of the Middlesex Hospital as demonstrator of anatomy, he now resigned his position in the army, and settled in practice in London. He passed the examination for the fellowship of the Royal College of Surgeons in May 1857, and next year was elected assistant surgeon to the Middlesex Hospital. He also became curator of the museum, and lecturer on comparative anatomy in the same institution. While holding these offices he published a work called "Diagrams of the Nerves of the Human Body," which has passed through three editions, and contributed the article on "Injuries of the Upper Extremities," which contained some original observations upon dislocations of the shoulder-joint, to Holmes's "System of Surgery." He also contributed a paper on the same subject to the Pathological Society, and several articles on various surgical subjects to the medical journals. In 1858 he married Georgiana Rosetta, youngest daughter of Admiral W. H. Smyth, F.R.S., the astronomer and hydrographer, whose son, Sir Warington Smyth, is so well known in Newcastle.

In 1861 the important office of Conservator of the Museum of the Royal College of Surgeons of England, commonly called the "Hunterian Museum," became vacant by the death of Professor Quekett. The collections under the conservator's charge are extensive and of very varied nature, embracing surgery, pathology, anatomy, physiology, zoology, and palæontology, and some knowledge of each of these subjects is required by the occupant of the office. The appointment was, however, congenial to Mr. Flower's tastes, and for it he relinquished the practice of his profession and his connexion with the Middlesex Hospital, and thenceforth devoted himself to scientific pursuits. The care of the Museum, and its complete reorganisation and gradual augmentation, constituted for many years his principal employment, every department having, unfortunately, fallen into arrears, as regards cataloguing and arrangement, when he took charge of it. The Hunterian Professorship of Comparative Anatomy and Physiology in the Royal College of Surgeons, which for twenty-five years had been held in conjunction with the Conservatorship of the Museum by Professor Owen, had been separated from it some time previously, and was now held by Professor Huxley, who, however, was compelled by the pressure of other engagements to relinquish it in 1869, when the two offices were again united by the appointment of Mr. Flower to the professorship. The duties attached to it consist in the delivery of a short course of lectures on a different subject each year, illustrated by the preparations of the Museum; and Professor Flower's addresses have contributed much to our knowledge of comparative anatomy. Thus his lectures delivered in 1870, on "The Osteology of the Mammalia," which have since been collected in a volume, and have gone through three editions, are well known to all biologists, and to most medical students. He has also lectured at the College on the "Cetacea," a group of animals to which he has devoted much attention; but his several series of Hunterian lectures on "The Comparative Anatomy of Man" should be specially noticed, as dealing with exceedingly difficult and complicated problems. In them he has traced the physiological racial characteristics of mankind with great clearness and accuracy, and has won much praise from the scientific world.

Professor Flower was elected a Fellow of the Royal Society in 1864, has served several times on the Council, and was vice-president in 1884-5. In 1879, on the death of the Marquis of Tweeddale, president of the Zoological Society, he was elected to succeed him in that office, having been many years previously a member of the Council, and one of the vice-presidents. He became a vice-president in 1879, and in 1883 was elected president of the Anthropological Institute of Great Britain and Ireland—a well-deserved honour. At the anniversary meeting of the Institute on January 22nd, 1884, he delivered a presidential address on "The Aims and Prospects of the Study of Anthropology," which, from his distinguished position in regard to that science, has a particular interest. In connexion with the British Association for the Advancement of Science, Professor Flower has held the offices of vice-president of section D (biology), presiding over the department of anatomy and physiology at the Norwich meeting in 1868. He was president of the section at the Dublin meeting in 1878, and president of the department of anthropology at the meeting at York in the year 1881. Again, in 1885, he was a vice-president of the Association at the Aberdeen meeting. At the Dublin meeting, he suggested to the association the formation of a committee of naturalists of various nations to deliberate upon the question of classification and nomenclature, upon the basis of the laws issued by the association in 1842. Professor Flower is also a vice-president of the Linnæan Society, and has long been prominently connected with the Royal Institution, before which he has delivered a number of lectures on subjects of biological and anthropological interest.

Professor Flower was president of the anatomical section of the International Medical Congress held in London in August, 1881, selecting as the subject of his inaugural address a history and description of the Museum of the Royal College of Surgeons. He has been several times an examiner for the Natural Science Tripos in the University of Cambridge, and, in 1878, received the honorary degree of LL.D. from the University of Dublin.

At the anniversary meeting of the Royal Society, in November, 1882, one of the Royal gold medals was awarded to him by the Council, in recognition of his services to science "in extending our knowledge of comparative anatomy and zoology in general, and of the mammalia in particular;" and because, as stated in the President's address when presenting the medal, "it is very largely due to his incessant and well-directed labours that the Museum of the Royal College of Surgeons at present contains the most complete, the best ordered, and the most accessible collection of materials for the study of vertebrate structures extant."

At the meeting of the Church Congress at Reading, in October, 1883, at the request of the committee, Professor Flower opened the discussion on "Recent Advances in Natural Science in their relation to the Christian Faith," by giving a simple and concise statement of the position of the doctrine of evolution, his object being to mitigate the prejudices of many of the strongest opponents of the doctrine amongst the clergy. The paper was printed in the report of the meeting.

In the year 1884, on the resignation of Sir Richard Owen, Professor Flower was appointed by the trustees of the British Museum to the important office of director of the new Natural History Museum at South Kensington. This necessitated the resignation of his appointment at the Royal College of Surgeons, which he had held for twenty-two years. On the occasion of the tercentenary of the University of Edinburgh, he was one of the distinguished men of science selected to receive the honorary degree of LL.D. He was also of the few whose services in the cause of knowledge were recognised in the "jubilee" *Gazette* of June 21st, 1887, when the Companionship of the Bath was conferred upon him.

Professor Flower is the author of numerous papers of great value upon anatomy, zoology, and the kindred sciences, a list of which may be seen in a work entitled "Contemporary Medical Men," to which we are indebted for the above short biography.

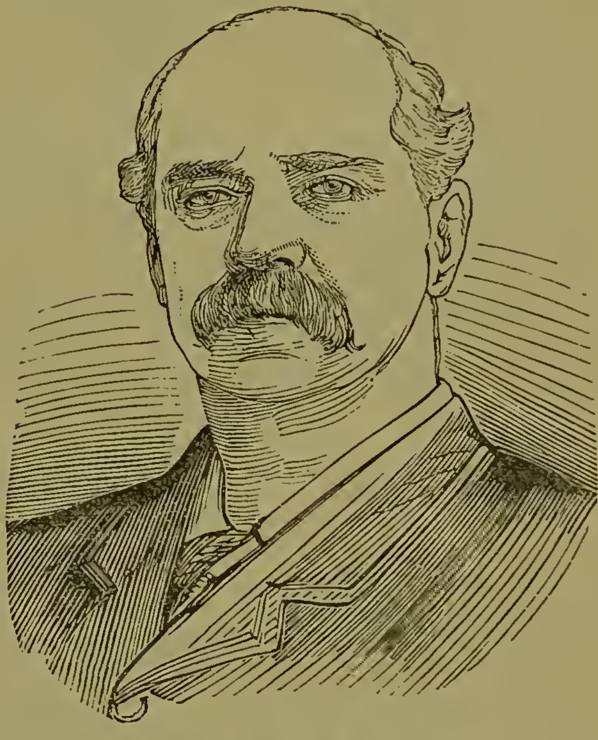
THE SECTIONS, THEIR WORK, AND THEIR PRESIDENTS.

In order to facilitate the reading and discussion of papers the British Association is divided into eight sections, viz.:—

A. Mathematical and Physical Science.
B. Chemical Science.
C. Geology.
D. Biology.
E. Geography.
F. Economic Science and Statistics.
G. Mechanical Science.
H. Anthropology.

The British Association brings together scientific men from all parts of the world to discuss subjects that are of importance, not only to the pure scientist who pursues knowledge for its own sake, but also to every one who is interested in the countless applications of science to the wants and aspirations of mankind. Besides the reading and discussion of papers, reports are presented at the annual meetings by committees specially selected to investigate particular problems; among the most important of which, in connexion with Section A, we may mention the Standards of Light, a subject of primary interest to all concerned with illuminants; the constructing and issuing of Practical Standards for use in Electrical Measurement; Electrolysis in its physical and chemical bearings; the Properties of Matter studied experimentally (Mr. P. T. Main's report), &c.

SECTION A.—MATHEMATICAL AND PHYSICAL SCIENCE.



CAPTAIN W. DE W. ABNEY,
R.E., C.B., F.R.S.,
PRESIDENT-ELECT: SECTION A.
(From a photograph, by Mr A. J. Melhuish, 12, Old Bond Street, W.)

The subjects treated in the papers read before this section cover a wide ground, and include the advances made, not only in pure mathematics, but also in those various offshoots of mathematics comprising astronomy and celestial physics on the one hand, and on the other mechanics, heat, acoustics, optics, and electricity.

A brief survey of some of the more striking advances during recent years, in the different branches of physics, will enable us to perceive the nature of the subjects that engage the attention of Section A, and at the same time, will show how important is the bearing of scientific principles upon industrial and other applications of science.

The full appreciation of the laws of thermodynamics is of the greatest importance to the theoretical development of the heat engine. The first law constitutes the principle of the conservation of energy as applied to the transformation of mechanical energy into heat, and *vice versa;* the number which expresses the mechanical equivalent of heat was determined by the classical experiments of Joule half a century ago, and his result has been confirmed by the more recent researches of Professor Rowland and others. The second law asserts that it is impossible to obtain, without compensation, mechanical energy from heat except by allowing it to pass from a body at a higher temperature, called the source, to a body at a lower temperature, called the refrigerator; and from it we can deduce the limiting efficiency that is possible with given temperatures of source and refrigerator.

The phonograph of Edison and the graphophone of Tainter and Bell are, at the present moment, attracting considerable attention, owing to the wonderful success that has rewarded the efforts of those who have been improving the original Edison phonograph of 1877, and certainly constitute the most interesting advance on the physical side of acoustics.

The spectrum forms the centre of attraction in the science of optics. The map of the solar spectrum has been obtained with very great accuracy, after many years of work, by Professor Rowland, of Baltimore. The spectrum was obtained by means of diffraction gratings, ruled on concave spherical surfaces by means of a machine provided with an almost perfect screw. The investigations of Captain Abney and Professor Langley have led to a very complete mapping of the invisible portion of the spectrum beyond the red. Abney employed special photographic methods, and so complete has been his success that our knowledge of this region begins to be comparable with that of the visible spectrum. Langley has endeavoured to ascertain the distribution of energy throughout the whole of the spectrum, and in his investigations has used an exceedingly sensitive instrument which he styles the "bolometer." The spectrum was obtained by means of one of Rowland's concave gratings, which obviated the necessity for the use of collimator, &c. By observations of solar radiation at high and low levels, he was able to estimate the radiation from the sun before the absorption and scattering which takes place in the earth's atmosphere.

At one time it was customary to speak of heat, light, and chemical rays as though there were certain rays that possessed alone the function of producing heat, light, or chemical effects. Abney has photographed by means of the ultra red rays, while Langley has proved that the ultra violet rays can produce heat effects; moreover, in the luminous spectrum, wherever light is deficient, as *e.g.*, in a Fraunhofer line, there also are deficient heat and chemical effects; so in other cases, we find for any particular ray, we cannot decrease any one of its effects in any ratio without simultaneously decreasing the other effects in the same ratio; hence we must consider heat, light, and chemical effects as being different results produced by the same radiation.

So great has been the advance of electrical science within recent years, that those interested are even asking for a separate section of the British Association for the consideration of electrical subjects, a demand which must, it would seem, be granted at no very distant date.

The discovery of the principle of the dynamo was made by Faraday in 1831; but it is only within recent years that the machine for the transformation of mechanical energy into electrical energy has been so perfected that the commercial success of electrical applications is fully assured. The incandescent lamp, with the discovery and development of which the name of Swan, of Newcastle, will always be remembered, has also played an important part in electrical progress. The success of the incandescent lamp depends upon obtaining a very good vacuum, and we may here insist on the importance of the work of those scientific men, especially Crookes, who, simply aiming at the advancement of knowledge, have contributed in no small degree to the development of the incandescent lamp.

On the theoretical side of the subject of electricity we must not omit to mention the very important investigations of Hertz, which were made known to the world in 1888, and formed the text of Professor Fitzgerald's address to Section A at Bath. Hertz has definitely proved that electromagnetic phenomena are due to the action of an intervening medium and not to a direct action at a distance. Dr. Lodge, in connexion with his work on Lightning Rods, had been led to perform experiments of a similar nature to some of those of Hertz. A new field of investigation has been opened up by these researches, and very interesting will be the results that experimenters in this branch may expect to obtain in the very near future.

The question of the lightning rod for the protection of buildings is of great practical importance, and although pending the performance of experiments on a grand scale, we are unable to express ourselves in the same dogmatic manner as of old; still, the necessity for greater precautions for the prevention of the electric discharge as lightning, by means of innumerable earth-connected pointed conductors, is clearly made out.

Captain Abney, the president-elect of Section A, was born in 1844. He belongs to an old Derbyshire family, and is the son of the Rev. Canon E. H. Abney, of Measham Hall, in that county, and Catherine, daughter of J. Strutt, Esq., of Beper. He was educated at Rossall School, and also privately. He went to Woolwich in 1860, was commissioned in the Royal Engineers in the following year, and was made captain in 1873. In 1864 he married Agnes Matilda, daugter of S. W. Smith, Esq., of Tickton Hall, Beverley. In the same year he went to India where he served till 1869. In 1870 he was appointed assistant instructor in electricity at the School of Military Engineering, Chatham, and in 1872 instructor in chemistry and photography. In 1876 he was appointed inspector in the science and art department, and in 1884 assistant director for science, which post he now holds.

Captain Abney commenced photographic studies in India in 1865, and in 1873 invented the system of photo-lithography called papyrotype which is now used for military purposes. He superintended the photographic arrangements for the 1874 Transit of Venus, and was one of the observers at Thebes.

In 1877 he was elected Fellow of the Royal

Society, and in 1884 was awarded the Rumford Medal of the Royal Society for his researches, by means of a photographic process on the dark rays of the spectrum to which reference has been made above. In 1878 he received the progress medal of the Photographic Society for his researches in photography. He is the author of numerous papers on this subject, which have appeared in the proceedings of the Royal Society, the *Photographic Journal*, and other papers. Also, with General Festing, F.R.S., he has contributed an important paper on the increase of radiation with the increase of electrical current through carbon filaments.

In 1886, Abney and Festing had so far completed their researches on colour photometry as to make it the subject of the Bakerian lecture of that year. By comparing the intensities of the several portions of the visible spectrum, using a modification of Rumford's method, they have drawn up a "luminosity curve." Their experiments with different individuals have given us additional insight into the nature of colour blindness. They have also investigated the atmospheric absorption of light.

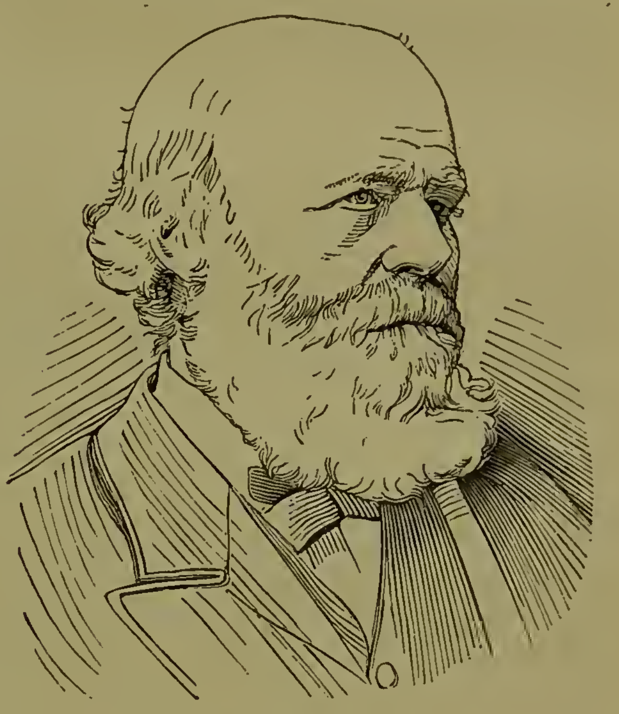
Captain Abney is the author of Thebes and its five greater temples ; joint author of Pioneers of the Alps ; author of various books on photography ; and editor of the last edition of Schellen on the Spectroscope.

He is a Fellow of the Chemical and Astronomical Societies, on the councils of which he has served, or is serving ; and is a vice-president of the Photographic Society. He is one of the British delegates to the Electrical Standards conference, and to the photographic conference. He is a member of the Alpine Club ; one of the executive committee of the present French International Exhibition ; a member of the Kew Committee ; and the inventor of the Abney level for survey purposes. In 1888 he was created a C.B., for his services to the War Office.

SECTION B.—CHEMICAL SCIENCE.

Though it is difficult in the limited space at our disposal to give even an outline of the subject, we aim at acquainting our readers with the main objects of chemistry. Briefly, it is the business of a chemist to know the composition of everything which has weight. By far the greatest number of bodies which we know in ordinary life are capable of being split up into their constituents. Chemists, however, distinguish some seventy odd substances which they have never been able to split up ; and though it is possible that many of these substances may after all turn out to be compounds, at present they baffle the ingenuity of chemists, who acknowledge their defeat by naming them "simple bodies" or "elements." Out of these seventy elements the whole body of matter is made up.

The first business of a chemist is to know all the elements and their properties ; his next is to discover what elements go to make up every conceivable body he meets with in nature. From these bodies his knowledge enables him to extract either the elements which they contain or some useful compounds thereof. Last and most difficult —having given a substance and knowing the elements of which it is made—comes the problem how to build it up from its elements, and in this, in many cases at least, chemists have been successful. Alizarine for example, the dye formerly extracted from the madder root, has been made and, in fact, is now exclusively made, from the tar of gas works. Similarly the colouring matter of indigo has been made from the same unpromising material. And it is not impossible that, as our methods improve, many more substances will in the future be artificially produced. It is even possible that the basis of fleshy tissue may be produced.



SIR LOWTHIAN BELL, BART.,
D.C.L., F.R.S., F.C.S.
PRESIDENT-ELECT : SECTION B.

It must not be supposed that all chemists are engaged in producing chemical products. The researches of the scientific chemist inevitably preceded every manufacturing operation. Many of the most important discoveries of science, most of the fundamental facts on which our industries depend, have been discovered by workers who worked from the pure love of truth and thirst for information, without which we believe that no one has made for himself a name in the annals of science.

In saying this, we do not wish to depreciate the man who, accepting the facts so painfully and unselfishly acquired, makes them the basis of a manufacturing process to the benefit of society at large. In Sir Lowthian Bell, however, it is not necessary to discriminate between the man of pure science and the manufacturer, since he combines the two functions in himself. Born in our midst, and associated as he is with the inception and progress of so many of our industries, it is unnecessary to do more here than give a short outline of his life.

Sir Lowthian Bell was educated in an eminently practical manner. After his early schooling in Newcastle, he visited France, Germany, and Denmark to acquire foreign languages and make himself acquainted with foreign scientific progress. Returning to his native place, he entered the ironworks of Messrs. Losh, Wilson, and Bell, at Walker, where his father was a partner. Various as are the other industries in which he engaged, he has never deserted this his original business. He has associated himself with it theoretically and practically, and we shall endeavour to show how wide a field of labour it affords.

The production of iron entails a knowledge of the places where the ore is to be found, of the qualities of the various ores, and of the chemical processes necessary to separate the iron from the other minerals present in them, processes which naturally vary with each description of ore. As fuel is almost as important as the ore, it is necessary to understand coal mining, the manufacture of coke, the best quality of coal for coke making, how to eliminate impurities from coke or to neutralise their effect on the iron produced. In the process alone of making iron in blast furnaces, the problems are so many that we could not in the space allotted to us enumerate them. The size and height of the furnace, the materials of which it is built, the nature of the action which produces the iron, the resulting gases, the air supplied, the temperature at which it should be used, and the effect of variation in all these numerous conditions are questions so complex that merely to learn all that is known of them is no contemptible work for the life of one man. On these subjects Sir Lowthian Bell has written books and papers, which are justly regarded as authorities. Not content, however, with the production of cast iron, Sir Lowthian's studies have extended to its conversion into wrought iron and steel. Steel, the metal of the day, could until recently only be made from cast iron practically free from phosphorus. The iron of the Cleveland district contains more phosphorus than is compatible with the production of good steel, and with the economical extraction of this phosphorus Sir Lowthian Bell has busied himself for years. It is no exaggeration to say that he and his firm have spent thousands of pounds over this problem, the solution of which seemed to have fallen to the lot of the inventor of the Thomas-Gilchrist process. Latterly, however, steelworks on an improved process have been erected at Clarence, and we believe that in them the production of steel from Cleveland iron has been solved.

Turning from the question of the manufacture of iron, of which no history would be complete which did not mention the subject of this memoir, the name of Sir Lowthian Bell is associated with the manufacture of those chemicals which are generally comprised under the name of alkali. Under his management, a process for the production of oxy-chloride of lead, invented by his father-in-law (the late H. L. Pattinson, F.R.S.) was carried to the stage of commercial success. More recently, salt mined from the beds of South Durham has been utilised by him for the production of soda by that process which now threatens the chemical industries of the Tyne.

Another chemical problem of this day, the production of aluminium, engaged the attention of Sir Lowthian Bell so long as twenty-five years ago. At Washington, in the county of Durham, a notable quantity of aluminium was made, but the demand at the then cost of production was not sufficient to encourage the industry.

If Sir Lowthian Bell were not so well known in the ranks of industrial science, his studies in economic science alone would render him notable. His long experience has rendered him an authority on the subject of work and wages, and the various economic problems which the relations between employer and employed have evoked all over the world. In this research he has been much assisted by his knowledge of foreign languages, which enables him to collect his information first hand.

Sir Lowthian Bell has been Sheriff of Newcastle-upon-Tyne, and has twice held the office of Mayor, being elected to that office on the last occasion to receive the members of the British Association at their meeting in 1863. He takes an active interest in several of the scientific societies, and has recently occupied the presidential chair of the Iron and Steel Institute and of the North of England Institute of Mining and mechanical engineers. He has acted as a juror at various exhibitions, and was made an officer of the Legion of Honour at the Paris Exhibition in 1878. In 1875-78, he represented Hartlepool in Parliament.

Sir Lowthian's youngest son, Charles Lowthian Bell, is one of the principal contributors to the industrial section of the local guide prepared for the meeting of the British Association; and his nephew, Hugh Lee Pattinson, jun., is one of the secretaries of the chemical section. Mr. Pattinson's father and grandfather held the same office in 1863 and 1838 respectively.

SECTION C.—GEOLOGY.

Section C has always been one of the best attended in the Association. One reason for this is, no doubt, the fact that of no science is it so easy to obtain a smattering as of geology. Another is probably best illustrated by the proverb, *omne ignotum pro magnifico*. A third reason is that professional geologists, though few when compared with chemists, biologists, or engineers, are generally remarkable for *esprit de corps*, form a compact body of whom the greater number are personally acquainted with one another, and stick very close to their Section. Indeed, the kind of genial freemasonry, not excluding occasional very lively discussions, exhibited by the members of Section C, both in their meeting room and on the, to them, all-important excursions, is one of the pleasing features of the annual gathering.

This popularity of Section C continues, it must be noted, notwithstanding the yearly increase in the specialisation—some would say in the dryness—of the papers read there. The times for broad generalisations in geology are almost past. The framework of the science is now agreed upon with but little likelihood of change. Most of the great questions in physical and stratigraphical geology, for which great fights were fought in the early days of the Association, which were also, it should be remembered, the early days of the science, are settled, and evoke, in the minds of older members, but the agreeable memories of past strife. Sub-aërial and marine denudation are no longer battle cries calling forth all the energies in attack and defence of such men as Murchison, Ramsay, Lyell, and Jukes. Ice, as a powerful agent of earth-sculpture is no longer regarded with grave suspicion as it was when the results of Agassiz's researches on Glaciers were championed by Buckland and by very few others. Wernerians, Huttonians, Vulcanists, Neptunists, Cataclysmists, and Uniformitarians are now mere names of historic interest only. There are, it may almost be said, nothing but details left to be discovered; and details notoriously demand more special knowledge than general questions. The papers now read are, therefore, more technical than those of former times. They require more careful investigations before they can be written, and give more trouble to criticise.

PROFESSOR JAMES GEIKIE,
LL.D., F.R.S.L. & E., F.G.S., &c.
PRESIDENT-ELECT: SECTION C.
(From a photograph, by Mr F. Gutekunst, Philadelphia.)

But if smaller subjects are now the rule in Section C, it cannot be denied that there are plenty of them. If the "geologist" of the old days—the great man who discoursed freely on every branch of the infant science—is no more, or is represented by one or two survivals at most, there are in his stead an enthusiastic army of specialists who, each in his own more or less limited sphere, labours as a field geologist, as a glacialist, as a stratigraphical geologist, as a vulcanologist, as a palæontologist (in many varieties) or as a petrologist. Division of labour is the order of the day, and we have even heard of a palæocarcinologist.

A necessary result of this general specialisation has been a very notable increase in the number of papers presented to the section, and, in consequence of this a sub-section is often formed, in which the "overflow" communications are read.

By an arrangement which has been found to work well at Bath, Manchester, and Birmingham it is contrived that the papers read in the sub-section are such as though, often of great importance from a strictly scientific point of view, are somewhat too technical to attract the general public. The audience in the sub-section are therefore not unusually more select than numerous. But in Newcastle there should be a public really interested in geology, however detailed and however technical. We refer to the many in this neighbourhood whose livelihood is directly or indirectly connected with mines. We have still with us the Boyds, Fosters, Daglishes, and Howses whose papers in 1863 were epoch-making as regards North-country geology, and took rank with those of Nicholas Wood, Winch, Buddle, King, Hutton, and others, no longer with us. Since 1863, however, a new race of geological mining engineers has sprung up, and to these we may safely look to keep up the honour of the North. Our collieries are storehouses of geological facts only a small portion of which have, as yet, been recorded, and those whose business leads them to observe these facts should take so good an opportunity as the British Association provides them with, to publish them and to get them discussed by the leaders of geological science.

Another arrangement, which is a convenient one, is that papers relating to local geology are, if possible, taken on the Friday of the meeting, so that the local writers may be certain of obtaining a proper hearing, and also in order that the strangers present may have an opportunity of being posted up to date in the more interesting features of the district before the first excursions, which take place on the Saturday.

The Thursday sectional work, of course, opens with the President's address, which, in the hands of Professor James Geikie, is sure to equal in importance the best of its many forerunners. Indeed, it may be said that Professor Geikie unites in himself, in a remarkable degree, the points which it is good that a president of Section C at Newcastle should possess. He has, since his entrance into manhood, until seven years ago, been engaged on the Government geological survey, and is therefore, to some extent, an engineer. He has specially distinguished himself by his researches on glacial deposits—those deposits which form so large a portion of the surface of Northumberland and Durham; he has a deep knowledge of the Carboniferous series, on which series Newcastle, fortunately for its prosperity, stands; and by the happy accident that much of his survey work was carried on in that part of Scotland which marches with Northumberland, he has had ample opportunities of acquiring a special knowledge of the rocks of the whole Border country. This last qualification is by no means a common one, and a president familiar with the region in which he presides has of late years been the exception rather than the rule.

It is impossible to speak of Professor James Geikie without mentioning his elder brother, Dr. Archibald Geikie. Both are equally eminent in the same science ; both began their scientific career as officers of the Geological Survey of Scotland ; the elder became first Murchison professor of geology in the University of Edinburgh in 1871, and the younger succeeded him in that post in 1882. Both possess the degree of LL.D. of St. Andrew's University, and both are distinguished Fellows of the Royal Societies of London and Edinburgh. Dr. Archibald Geikie was director of the Geological Survey of Scotland, while his brother held the District Surveyorship in the same service, and he is now Director-General of the Geological Survey of Great Britain and Ireland. Professor James Geikie resigned his connexion with the Survey on his appointment to the Edinburgh Professorship, which he still holds. Both have written largely on the geology of Scotland and on glacial geology generally, and both have also written excellent text-books of their favourite science.

Under these circumstances, it is scarcely to be wondered at if some confusion may at times exist in the minds of the uninitiated as to the identity of these remarkable men. Let it be remembered that Professor James Geikie is chiefly noted for his very original and widely-known views on glacial questions. These views he has given to the world in the "Great Ice Age," a large and detailed work of which in a short time a second edition was called for, and in an equally elaborate book "Prehistoric Europe," dealing with the same subject on an extended scale. He has also taken much interest in the formation and in the proceedings of the Royal Scottish Geographical Society, and by his lectures in various parts of the country has spread a knowledge of his views on geographical evolution far and wide. His joint report with Sir Andrew Ramsay on the Geology of Gibraltar is the classical memoir on the subject. Professor Geikie is still comparatively a young man, and much good work is left for him to do. That he will do it, and do it well, no one who knows his love of his science, his painstaking accuracy, and his activity both of body and mind, can for a moment doubt.

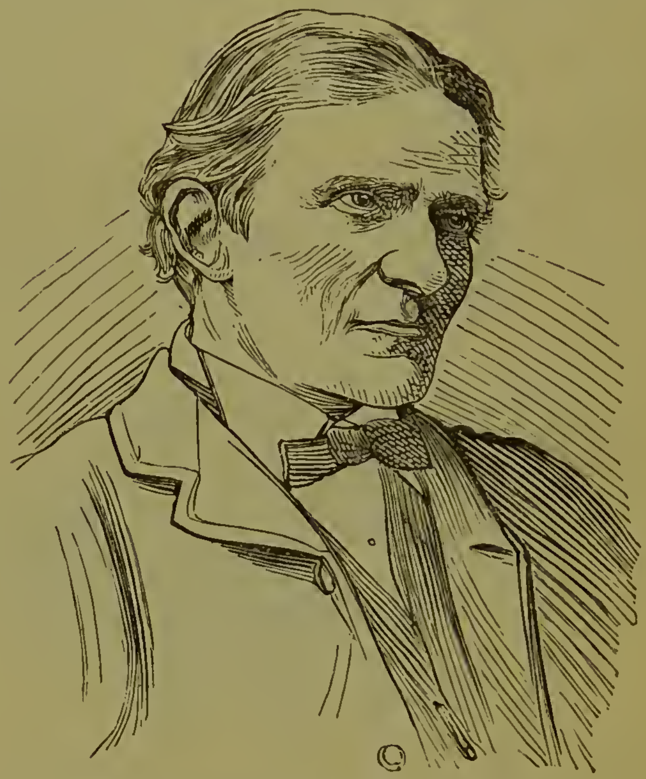
SECTION D.—BIOLOGY.

Biology is the science of life, and includes botany, plant life ; and zoology, animal life. Both plants and animals are rightly included in the science of life, because they are essentially the same in composition, one elementary substance—protoplasm, underlying both. The properties of protoplasm were described a few years ago by Professor Huxley, who showed that all living matter is prosoplasm in one form or another.

The president of this section is descended from an old Northumbrian family, his great-grandfather having lived on his own land at Brunton. His grandfather, Sir Thomas Burdon, amassed considerable wealth as a brewer, and bought some land at Jesmond. This became the property of Richard Burdon, the father of Professor Sanderson, and upon it was built the nucleus of the mansion now in the possession of Mr. C. Mitchell. Sir Thomas Burdon married Jane Scott, the sister of John Scott (Lord Eldon), and William Scott (Lord Stowell.) We may presume that intellectual ability was not confined to the male members of this gifted family.

The family name of "Burdon-Sanderson" is of recent date. When Richard Burdon, the father of our president, married the daughter of Sir James Sanderson, Bart., a London merchant, he took her name, and from this union the compound name has risen.

Having received his scientific and medical education in Edinburgh and Paris, Dr. Burdon-Sanderson settled in London in 1855. From this date to 1870 he was principally engaged as Medical Officer of Health in one of the metropolitan districts, and in carrying out sanitary inquiries entrusted to him from time to time by the Medical Department of the Privy Council and the Local Government Board. He was also a member of the Staff of the Middlesex Hospital, and the hospital for consumption at Brompton.



PROFESSOR J. S. BURDON-SANDERSON,
M.D., LL.D., F.R.S.,
PRESIDENT-ELECT: SECTION D.
(Engraved from a photograph, by kind permission of Messrs Elliot and Fry, 55, Baker Street, W.)

In 1870, Dr. Burdon-Sanderson resigned his hospital appointments to devote himself to physiology and experimental pathology. With this object in view, he opened a private laboratory in the neighbourhood of Tottenham Court Road. Shortly after this he was appointed, by the Senate of the University of London, superintendent of the newly-established "Brown Institution," an institution which is devoted to the treatment of diseased animals of all kinds, and here, in co-operation with Dr. Klein and others, he conducted numerous researches relating to the nature and causes of infectious disease in man and animals. This, now the well-known study of comparative pathology, was in those days quite a new departure. Out of it has come the wide-spread knowledge which we at present possess of the dependence of the so-called specific or infectious diseases upon minute organisms known by the names of microbes or bacteria.

Recognising the sharpness of the line which separates health from ill-health—physiology, a description of normal function from pathology, that of abnormal function—Dr. Burdon-Sanderson's work has embraced both of these subjects. He is therefore not less known as a pathologist than a physiologist and, so far as these two branches of science are concerned, he has hitherto regarded the experimental or inductive method as the great avenue along which increase of knowledge is possible.

In 1875, Dr. Burdon-Sanderson succeeded the late Dr. Sharpey as Professor of Physiology at University College, London. Previous to this, however, Dr. Sanderson's reports on "Suspended Animation," and the best methods of restoring the apparently drowned, together with numerous other papers published in the Philosophical Transactions and in those of the Royal Society, had attracted much attention. As the result of numerous experiments undertaken to ascertain the most effectual means of restoring the drowned, he showed that Dr. Sylvester's, as opposed to Dr. Marshall Hall's, is the superior method. That method is now adopted by the Humane Society.

The year 1872 saw the publication of what at that time was recognised as something more than a novelty—viz., a "Handbook for the Physiological Laboratory." This was the joint production of three well-known physiologists—Professor Michael Foster, of Cambridge, Dr. Lauder Brunton, of St. Bartholomew's, and Professor Sanderson.

At the suggestion of Mr. Darwin, Dr. Sanderson undertook some experimental work in connexion with plant electricity, which led to the discovery of the fact that, in the irritable part of plants, the excitatory state is accompanied by electrical changes which stand exactly in the same relation to it as in the nerves, muscles, and electrical organs of animals; and that consequently the process of excitation in the two kingdoms is of the same nature. It was scarcely to be expected that such a startling announcement would be allowed to pass unchallenged. Other minds, particularly on the Continent, had already been drawn into this groove. It was no surprise, therefore, when Professor Münk, a well-known German physiologist, combated the views of Professor Burdon-Sanderson; not lightly, nor after any theoretical fashion, but after numerous investigations. Later researches, however, have rather tended to confirm than overthrow the theories advanced by Dr. Sanderson, whose most recent papers to the Royal Society on the Electrical Organs of the Skate and also of the plant Dionea, are regarded as the standard works on this subject.

It is clear that whilst Dr. Sanderson's relationship to the Brown Institution afforded him abundant opportunities for carrying out his observations upon subjects of an all-engrossing character and of great interest, his duties as Professor of Physiology at University College, and the obligations incumbent upon him as a teacher, made calls upon his time and restrictions upon his leisure that he could not but regard. Severing, therefore, his official connexion with the Brown Institution, he devoted his whole time to the establishment of a research laboratory in connexion with his professorship. This new physiological laboratory was opened at University College in 1880, since which it has afforded opportunities for all kinds of research work. Dr. Sanderson's personal superintendence of this, however, was short lived, for in 1882 a new Chair of Physiology was established in Oxford which Professor Burdon-Sanderson accepted, though not without reluctance.

Though instruction in medicine had been successfully given at Cambridge for many years, and had attracted a large number of students, this subject had been neglected at Oxford. The work, therefore, was new; a fresh start had to be made, and that under considerable opposition. It is to Professor Sanderson's credit that as the result of his association with Oxford there is now not only a large physiological laboratory, but a well organised and fully equipped department of human anatomy under the direction of a University lecturer, and Oxford is now capable of placing every facility at the disposal of the student of medicine for preparing himself for his first two professional examinations. From what we have seen of the museum, well stocked libraries and laboratories, we cannot but think that medical teaching there has a brilliant future before it.

If we have dealt at length with the purely technical career of Professor Sanderson, it is because of late years he has been principally engaged with physiology and its application to medicine. Nevertheless, his work in the field of experimental pathology is just as solid, and will be as enduring. When in 1866 farmers in this country were being ruined by the cattle plague, and a Royal Commission had been appointed to inquire into its origin and means of propagation, it was Dr. Sanderson's fortune to show that in this disease the serum of the blood is capable of communicating the disease by inoculation, and that it contains the virus in such a form that it can pass through an animal membrane. Cholera, too, received some elucidation from his pen. If, however, there is one subject in pathology which Professor Burdon-Sanderson has enriched, it is that of tuberculosis. Consumption has ever been a theme of fascination for the highest minds in medicine. Until the middle of the present century the opinions held and taught by our medical men were those of the French school. Laënnec, Piorry, and others had shown how consumption was to be regarded as the local expression in the lungs of a weak constitutional state, inherited for the most part. Having influenced the thought and practice of medicine for several decades, this teaching became gradually replaced by that of German pathologists, who showed by experiments that tubercle — the anatomical substratum of consumption — was not necessarily due to any special constitutional flaw, but was due to absorption of some putrid material from diseased glands within the body. Into what was then a spirited discussion—one not yet settled—Professor Sanderson threw all his energy and ability, and again he employed the experimental method. Two elaborate reports to the Privy Council (1867-68) embody his views upon the pathological effects of the inoculation of tuberculous material. These papers give the first account of the pathological histology of "artificial tuberculosis," and the first demonstration of its anatomical relation to the lymphatic system—views subsequently confirmed by later writers, notably Dr. Klein. One other point he also brought out, viz., the possibility of tubercular consumption arising as the result of an accident or injury.

To the study of minute organisms, *e.g.*, microzymes or bacteria, and the part they play in disease, Prof. Sanderson also devoted considerable attention. In his earliest researches on the subject he showed by experiments on vaccine that in this disease the contagion is due to the presence of particles of extreme minuteness to which he gave the name "particulate." These particles are organised beings. Subsequently he investigated the origin and distribution of microzymes in water, the result of which enabled him to prove that, as a rule, water is the medium by which the germinal material of bacteria is conveyed; that water of every kind can induce putrefaction in soils capable thereof, and that distilled water, although at first sterile, soon becomes possessed of germinal properties. Along with his coadjutor at the Brown Institution, Dr. Klein, Professor Burdon-Sanderson published in 1872 a paper on the "Infective products of inflammation," in which was shown the conditions under which acute septic infection arises in consequence of wounds, and how closely tuberculosis is allied to infectious diseases. In 1882, Dr. Sanderson was appointed Lumleian Lecturer at the Royal College of Physicians. The lectures there delivered contained a summary of the work which he had done up till that time, and enabled him to review the great advance pathology had made in the two preceding decades.

Idleness is not a vice Professor Burdon-Sanderson can be charged with. The long list of papers he has written is the record of a life faithfully devoted to science and to the utilisation of the facts of general science for medical purposes. There are few objects in life nobler.

Promotion has naturally followed in the footsteps of Professor Sanderson, the highest scientific societies showing their appreciation of his valuable work; and the British Association, in making him President of the section of Biology, has marked its appreciation of the life and labours of this distinguished son of the North.

In 1853, Dr. Burdon-Sanderson married Ghetal, daughter of the late Rev. R. N. Herschell, and sister of Lord Herschell, formerly M.P. for Durham.

SECTION E.—GEOGRAPHY.

In writing of the work of the sections, we have found a difficulty in defining the scope of each; and it is certainly hard to say what may not be included under "Geography" in the broad acceptation of the term. This difficulty is illustrated by the history of the section. At the first meeting of the British Association in Newcastle, geography held a subordinate position in connexion with the Geological Section; at the following meeting in Newcastle—viz., that held in 1863—geography held the chief place in a section devoted to geography and ethnology, under the presidency of Sir R. J. Murchison, K.C.B., F.R.S.; and it was not until the Exeter meeting, in 1869, that ethnology was separated from geography, and attached (as anthropology) to biology, geography thenceward having a section to itself. At Exeter, Sir Bartle Frere, K.C.B., LL.D., was the president.

COLONEL SIR FRANCIS W. DE WINTON,
R.A., K.C.M.G., HON. SEC. F.R.S.,
PRESIDENT-ELECT: SECTION E.
(Engraved from a photograph, by kind permission of Messrs Adams and Scanlan, Southampton.)

In a commercial centre like Newcastle we may fairly assume that the practical applications of geographical knowledge will receive prominent treatment by this section; and occasion may be taken to show what work has been done to open up markets for our goods, such work, for example, as Captain Wiggins, Mr. Sulivan, and others are endeavouring to accomplish in Siberia.

The study of this subject has been sadly neglected in England, birthplace though it be of so many of the most eminent practical geographers—of Baker and Markham, former presidents of this section ; of Grant, who attended the last meeting of the British Association in Newcastle ; of Stanley, and of Joseph Thomson.

We are, however, at last awakening to the importance of a systematised study of this subject ; and it will be doubtless the work of the Geographical Section of the British Association not only to enlarge our knowledge of certain sections of the world, but also to take up the highly important question of geographical education. In 1884, the Royal Geographical Society appointed their librarian, Mr. J. Scott Keltie (Recorder of Section E) as their inspector of geographical education, empowering him to visit the educational establishments of the continent and to report upon the attention paid to the teaching of geography and to the manner of, and appliances used, in imparting a knowledge of this science. His report, published in 1886, is most unfavourable to us. We, to whom, as travellers, as emigrants, as soldiers, as sailors, as rulers of many people, geography should be a study of more importance than to any other nation, are informed that "Geography in this country is almost entirely neglected as a subject of education. In our universities it is *nil*, in our public schools very nearly *nil*. We have neither competent instructors, proper text books, nor decent maps and appliances." To find how geography should be taught, we may go to any country in Europe but our own. Yet there is no study more interesting to the scholar, of more value to the practical man, be he engineer or trader, as well as to the historian, more suited for developing the thinking powers, more unprofitable to the crammer. We hope that one good result of the meetings of this section will be that parents will insist on greater attention being paid to this subject in our schools, and that our educational leaders will respond to the demand for higher and wider instruction in it.

When geography is regarded as a study of the dwelling place of humanity, as the theatre in which he exercises all his activities, its practical value is evident. The influence of geographical features in the course of history, in industrial development, in the establishment of trade routes, on colonisation, is rapidly being recognised ; and the subject is therefore being raised to a higher platform in education than it has held hitherto, when it was regarded as little more than lists of names. At last, owing to the exertions of the Royal Geographical Society, we have chairs of geography in Oxford and Cambridge, the subject is making way in middle class schools ; it holds an important place in elementary schools ; and in time there will be in the market greatly improved text-books, maps, atlases, models, and pictures.

We have our recently formed Tyneside Geographical Society. Like all such institutions, it owes its life to the exertions of one or two men. But besides an indefatigable secretary and a few active members of council, it needs subscribers to its funds and claimants of its benefits. The society's rooms and library in Collingwood Street, close to the Town Hall, are being more and more used by those in search of information about our colonies. This society has by its lectures and other influences done something to awaken in this locality a greater interest in geography.

Twenty-six years ago, when the last Newcastle meeting was held, it was a stirring time in the geographical world. Then, as now, the Bath and Newcastle meetings came together, the Bath meeting, however, coming after, instead of before, Newcastle. At Bath, Livingstone, who had just come home, described to a great audience the story of the Zambezi's explorations. Bates, now secretary of the Royal Geographical Society, who will be with us in September, had just come home from the Amazon: Captain Burton was in full progress. The previous year Mr. Donald Stewart described his journey across Australia, and M. Vambery his visit to Central Asia, and A. R. Wallace his experiences in the Malay Archipelago. At Newcastle 25 years ago, Captain (now Colonel) Grant told the thrilling story of the discovery by himself and Speke of the source of the Nile, when Mr. A. R. Wallace also honoured us with his presence. Since then exploration, especially in Africa, has so advanced that it is not so easy to get hold of thrilling stories of adventure as it was a quarter of a century ago. But there is likely to be no lack of interest in this section, which, indeed, has always been one of the most popular sections of the Association.

The president this year is Colonel Sir Francis Walter de Winton, R.A., K.C.M.G., and is the younger son of the late Walter de Winton, Esq., M.P., Maeslolioch Castle, Radnorshire, and his wife, Julia Cecilia, second daughter of the late Rev. John Collinson, for so many years rector of Gateshead, Sir Francis's mother was born at Gateshead Rectory and lived there till her marriage, and many months of his childhood were spent at Boldon Rectory (to which his grandfather had been presented soon after his birth).

Sir Francis was educated at Woolwich, and received a commission in the Royal Artillery in April, 1854. In November of that year, he was sent out to the Crimea, where, though wounded in the trenches, he was still able to be present at the taking of Sebastopol. He received the Crimean Medal and the Cross of the Legion of Honour. From 1860 to 1865 he was aide-de-camp to the late Sir Fenwick Williams of Kars, then commanding the forces in British North America ; from 1865 to 1867, private secretary to Sir Fenwick while Governor of Nova Scotia. In 1870 he again accompanied Sir Fenwick Williams as aide-de-camp to Gibraltar for five years, and in 1877-78 was one of the military attachés at Constantinople during the Russian and Turkish War. At the end of 1878 he accompanied the Marquis of Lorne to Canada as military secretary. On his return in 1883, he was quartered at Newcastle-on-Tyne in command of the Royal Artillery for about two months, when he was selected by the King of the Belgians to replace General Gordon, whose services were required in Egypt. From 1884-1886, he was Administrator-General of the Congo. In 1887 he was sent out to the West Coast of Africa in command of the Yonnil Expedition, and having brought this to a successful issue in three months, he returned, and in 1888 was appointed Assistant Quarter-Master-General at the Horse Guards, which post he now holds.

Besides the Crimean medal and the Cross of the Legion of Honour, Sir Francis has received the Orders of Knight Commander of St. Michael and St. George, Commander of the Bath and of the Order of Leopold. He has also received the Star of the Congo.

Colonel de Winton has always taken great interest in geographical science, and was a member of the Council of the Royal Geographical Society. He was particularly engaged in explorations on the Congo, and has contributed much valuable information on that district, and since his return has lectured in England on the subject. On the retirement of Mr. Clements Markham from the post of joint-secretary of the Royal Geographical Society, Colonel de Winton succeeded him, his colleague being Mr. Douglas Freshfield. He is also secretary to the Emin Pasha Relief Committee. In 1864 Sir Francis married Evelyn, daughter of C. Rawson, Esq.

SECTION F.—ECONOMIC SCIENCE AND STATISTICS.

With the exception perhaps of Section E (Geography), Section F is that which has the most interest for the general public. It is not that political economy and statistical science require less previous training in their students than do the other sciences, but that their subject matter is familiar to all, and, whereas nearly all the physical sciences can be approached only through mathematics, there is no such obstacle in the case of political economy to bar the way of the man of ordinary education. Nor is the path of political economy made thorny by a technical phraseology; the words of many syllables and Greek derivations which stud the pages of other sciences are conspicuous by their absence, to the comfort of the student, though frequently to the confusion of the professors, from politico-economical treatises. While thus open to all who choose to turn to it, the science of political economy is of interest to all without exception. The chemistry section will be of special interest, of course, to all concerned in chemical works, the geology section to all concerned in mining, the mechanical section to shipbuilders, electricians, the makers of ship canals, and engineers generally. But Section F. concerns all these, and the public at large as well. For the object of all these is wealth, and the subject of political economy is wealth, the laws according to which wealth is produced, exchanged, distributed, and consumed. No chemical manufacturer could think of doubting the utility of chemical science, no mine owner of geological science, no engineer of mechanics. The services rendered by these sciences to the arts and manufactures based on them are too obvious to be called in question. The value of political economy to every one who produces, exchanges, or consumes wealth, and who chooses to avail himself of the scientific truths which it teaches, is quite as great and quite as direct as that of any physical science. Valuable, however, as political economy is to all engaged in commerce, its utility is not restricted to commercial purposes. Wealth is the basis and the indispensable condition of all social progress. The science of wealth, therefore, must provide the premises from which any sound scheme of social reform is to be deduced. If it is alleged that wealth is distributed with dangerous inequality, and that reform is urgent, the first step to take in order to reform is to ascertain how, as a matter of fact, wealth is distributed. And the laws of the distribution of wealth form one department of political economy. If platform orators teach that the sole source of wealth is labour, and that, therefore, the landlord and the capitalist should be despoiled, the first point on which to instruct them is how wealth is produced. And the laws of the production of wealth form another part of the science. Thus far we have spoken exclusively of political economy: the practical value of statistics is equally great.

PROFESSOR F. Y. EDGEWORTH,
M.A., F.S.S.,
PRESIDENT-ELECT: SECTION F.
(Engraved from a photograph, by kind permission of Messrs Adams and Scanlan, Southampton.)

A man of business can hardly know his own business well if he knows nothing else; and even his own he can know only so far as he knows it methodically. And without precision there is no true method. It is unfortunate that figures—the only popular exponent of precision—have been recklessly and even dishonestly used. It is a pity that they admit so readily of such use. But edged tools have a like reputation. And figures, after all, as appealing to number, are very useful, when rightly used (not abused). They help us to the mode of precision most available for ordinary purposes. There is no judgment without differing of cases (and that is analysis), and there is no comparison of quantities without figures (and that is enumeration), and if abuse condemned the great things we have, how many of them should we keep?

It is true that the use of statistics is an art, but so is every application of skill to practice—baking, weaving, and building—and though the baker, the weaver, or the builder having his art at his finger ends has little or no aid from figures, he cannot usefully know much that concerns him in his art without their aid. It is not the mere figures he wants. It is their significance, as giving quantities and the relations of these to each other. And the wider his knowledge of what concerns him, the more is he driven to rely on the convenient signs for the formation of clear ideas of what he is about. They give needful precision to his knowledge, and enable him to fit it to the due effecting of his purposes.

And if, quitting the shop, where he earns his money, he turns to his home, where he spends it, it is the same; and if he reads his paper, and learns how he is governed, and taxed, and protected from those who would molest him, at home and abroad, he must use statistics, if he would judge correctly and see clearly what he is about.

All the businesses and arts and pursuits of other men are directly related to our own. All go on and thrive because they are so, and prosper or decay according to the due maintenance of a good relation between them, and no question about them can be clearly put or usefully answered without statistics.

In short, they form the bookkeeping of life, and we know what sort of men can and do dispense with the bookkeeping, and what happens to those who, needing, neglect it.

With regard to the history of the section, Section F has, as we have said, two branches—Statistics and Political Economy. Of these the former is coeval with the Association; the latter was grafted on about a quarter of a century later. The branch which has been longest in existence has naturally borne most fruit.

It may be safely said that some at least of the principal investigations which the most eminent English statisticians have produced during the last half century have first seen the light in Section F of the British Association. It is sufficient to allude to the researches of Porter on the Progress of the Nation; of Neison on Vital Statistics; Newmarch and Cairnes on Gold; Jevons on Commercial Fluctuations; Leone Levi on Wages; and R. Inglis Palgrave on Banking.

The fruits of the economic branch, if less abundant, have not been inferior in quality. Probably the greatest advance in abstract economics which has been made within the last half century is the completion of the theory of value which was effected by Jevons. His theory of "final utility" is ranked by many in respect of importance with the doctrine of "natural value" and "cost of production" connected with the names of Adams, Smith, and Ricardo. Jevons's theory was first propounded at the British Association in 1862.

We may allude also to the discussion of the logical method of political economy which was initiated by Professor Ingram at the last Dublin meeting (1878), and which Professor Sidgwick has carried forward in the masterly presidential address given by him in 1885 at Aberdeen.

Among other eminent presidents of the section, most of whom have contributed important addresses, we may notice Babbage, Hallam, Senior, Newmarch, Fawcett, Jevons, Professor Thorold Rogers, and Mr. Inglis Palgrave, F.R.S.

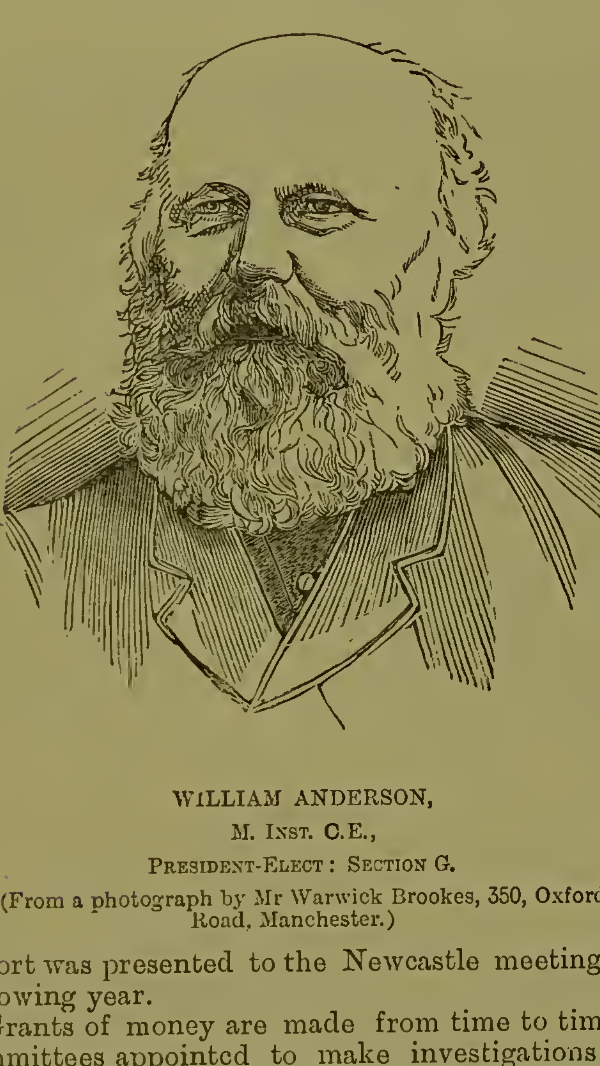
Amongst the secretaries of the section in past years it is interesting to note the names of J. T. Danson, the author of "The Wealth of Households" (who, in 1834, was secretary when Tooke was president, and is now engaged on the completion of the great work on the history of prices) of Professor Cairnes, Professor Leone Levi, and W. Newmarch.

Professor Edgeworth (who is a nephew of the authoress, Maria Edgeworth) was born and educated at Edgeworthstown, Ireland. Entering Trinity College, Dublin, at an early age, he took some of the highest honours in classics. He obtained a scholarship, and was first of the first class in classical honours. From Dublin he migrated to Oxford, where he became a member of Balliol College. He took a first class in the final classical school ("Greats.") He afterwards devoted some years to the study of mathematics. He is the author of several papers on the Calculus of Probabilities, and the Mathematical Theory of Statistics, published in the transactions of the Cambridge Philosophical Society, the London Philosophical Magazine, the Journal of the Statistical Society, and collected by the author in a little treatise on the art of measurement. (Temple Publishing Company.) Mr. Edgeworth has been appointed secretary to several committees named by the British Association to report on certain monetary problems. He has been secretary to the Economic Section of the British Association. He is a member of the Council of the Royal Statistical Society, and Examiner in Political Economy to the College of Preceptors. He is member of the English bar, and has been on the staff of King's College for eight years. He is author of several works on questions of ethics and political economy.

SECTION G.—MECHANICAL SCIENCE.

Telford has defined the profession of a civil engineer as "the art of directing the great sources of power in nature for the use and convenience of man." And as this section includes military engineering, which hardly comes within the field of Telford's definition, wide though it be, it will be seen that the range of subjects embraced by Section G is a very extensive one.

We note that, amongst many others, papers have been read and discussed upon the use of wire ropes in deep mines by Count Augustus Breunner, in 1838, at the first Newcastle meeting, some years, we believe, before they came into general use in England; mining records, firedamp, and levelling staves; marine engines and the form of ships; the strength of materials, cast iron for railway sleepers, the oxydation of rails, and resistance to traction on railways; electrical standards, the graphophone and phonograph, canals, docks, and water supply, Sopwith's monocleide and the application of gun-cotton to warlike purposes. No subject, in fact, likely to be of interest to the engineer is excluded from the consideration of the section, and many important discoveries have been first given to the world through the medium of the British Association, as, for example, Schönbein's discovery of gun-cotton at Southampton in 1846, and the Bessemer process for making steel in 1856 at the Cheltenham meeting. Preece first exhibited the telephone in this country at the Plymouth meeting in 1877, and Edison's phonograph was first publicly exhibited at Bath, last year, by Colonel Gouraud. The electrical units, too, in use throughout the world were originated by a committee of the British Association appointed at Cambridge in 1862, and their first report was presented to the Newcastle meeting the following year.



WILLIAM ANDERSON,
M. INST. C.E.,
PRESIDENT-ELECT: SECTION G.
(From a photograph by Mr Warwick Brookes, 350, Oxford Road, Manchester.)

Grants of money are made from time to time to committees appointed to make investigations and carry out experiments, the reports of which are published from year to year by the Association. Amongst these we may mention the reports upon tides, to which £2,670 has been devoted; waves, forms of vessels, &c., £2,440; underground temperature and coal mining, £112; electrical standards, £807; and the strength of materials, &c., £915. Altogether, about £9,600 has been spent by the British Association, since its foundation in 1831, upon questions of interest to the engineer.

When the British Association was first constituted at York, in 1831, a distinct section for mechanical science was not contemplated. At least no mechanical science section appears upon the list, and it was not until the Bristol meeting, in 1836, that this section was formed. The president was Davis Gilbert, D.C.L., F.R.S., and he has been succeeded from year to year by a long line of illustrious engineers. Amongst these we may mention Charles Babbage, F.R.S., and the Rev. Prof. Willis, M.A., F.R.S., who presided at the Newcastle meetings of 1838 and 1863 respectively; Robert Stephenson, M.P., F.R.S., at Birmingham, in 1849; Sir W. G. Armstrong, LL.D., F.R.S., at Birmingham, in 1865, and again at York, in 1881.

The president-elect for this year is William Anderson, M.Inst. C.E. He is a descendant of an old Newcastle family, some of the representatives of which still live in Newcastle. His ancestors emigrated to St. Petersburgh about the middle of last century, and members of the family still carry on, under the name of Matthew Anderson and Co., what is known as the Baltic trade.

The subject of this notice was born in St. Petersburg on January 5th, 1835. He obtained his early education at the High Commercial School in his native city, and when he left in 1849 he was head of the school, silver medallist, and, although a British subject, had conferred on him the freedom of the city of St. Petersburg. The school was an exceptionally good one for a boy with a decided bent for engineering, because science and four modern languages formed the entire curriculum. Great pains were taken to make the boys speak the languages, to which end French, English, and German masters had each charge of the school, twice a week, and the language of the master for the day was the language of the school. The Russian language, as far as speaking went, was allowed to take care of itself.

In 1849 Mr. Anderson became a matriculated student in the applied sciences department of King's College, London, and went through the complete three years' course, taking many prizes, and leaving in 1851 with the degree of associate, to become a pupil of the late Sir William Fairbairn, at Manchester. He remained with Messrs. William Fairbairn and Sons for three years, and during that time was much employed in looking after important outwork. In 1855 Mr. Anderson entered into partnership with Messrs. Courtney and Stephens, of Dublin, and remained with them till 1864, being engaged chiefly in the construction of bridges, cranes, signals, and other fittings for railways. He devoted much attention to the theory of diagonally-braced girders, then but little understood, and contributed several papers to the Institution of Civil Engineers of Ireland, of which body he became president in 1863. In the autumn of 1864 Mr. Anderson removed to London, joining the old-established firm of Easton and Amos, with the object of building new works on the Thames at Erith, the old premises in Southwark Street having been found inconvenient for large and heavy work. The Erith works have been gradually extended, and are at the present time among the largest in the country. Their position on the Thames, together with direct communication with the South-Eastern railway system, giving exceptional facilities for home and foreign work.

Mr. Anderson, under whose direct management the Erith works have been since their erection, is now the head of the firm of Easton and Anderson. He is a member of the council of the Institution of Civil Engineers, a Vice-president of the Institution of Mechanical Engineers, a Visitor of the Royal Institution, a member of council of the Society of Arts, and has contributed numerous papers on a variety of subjects to these bodies. His knowledge of the Russian language has enabled him to compile many interesting papers for the foreign abstracts published by the Institution of Civil Engineers. He has also translated the remarkable works of Chernoff on steel, and the researches of the late General Kalakoutsky on the internal stresses in cast iron and steel. He was selected by the Institution of Civil Engineers to deliver one of the series of lectures on Heat namely, that on the generation of steam; by the School of Military Engineering at Chatham to lecture on hydraulic machinery and on hydropneumatic Moncrieff gun carriages; and delivered for the Society of Arts, under the Howard Trust, a course of lectures on the conversion of heat into work.

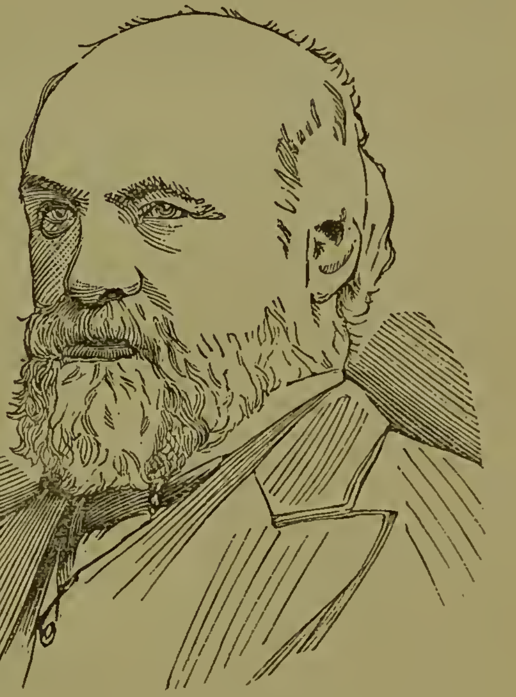
It is interesting to note that many of the men who have filled the subordinate office of secretary to this section have since distinguished themselves in their profession. The names of Percy Westmacott, Scott Russell, Emerson Bainbridge, Le Neve Foster, H. M. Brunel, Abernethy, Vignoles, Manby, and Hawkes are familiar to all engineers; and A. T. Atchison, the present energetic secretary of the British Association, was for nine years one of the secretaries of Section G.

SECTION H.—ANTHROPOLOGY.

In a country like ours, which has colonies and dependencies distributed over the whole earth, the study of anthropology—the science of man—should be popular. The range of this subject is extensive, the anatomist, the physiologist, the psychologist, the geologist, the archæologist, the philologist, the historian, and the student of political economy are equally interested in it, and the people of England, above all others, whose commerce brings them in contact with so many different races, would find that a competent knowledge of this science would increase their prosperity by facilitating their intercourse with savage as well as civilised peoples.

It is a fair question, and one that is sure to be asked by practical men in this nineteenth century, What is the use of anthropology? What practical bearing can it have on human welfare? It is a question not difficult to answer, for the anthropologist, it must be remembered, does not content himself with the investigation of man's origin and development, but he goes on to consider the laws by which his life is now regulated. The influence of climate, the causes of the deterioration or extinction of certain races, the development of civilisation, the effect of different occupations, are subjects the study of which will enable us with more or less certainty to determine what each man is best suited for, and to avoid the fatal mistake of trying to fit square men into round holes. The word anthropology is derived from two Greek words: *anthropos*, man, and *logos*, a discourse. The term is, therefore, one of extremely wide meaning, and the science may be said to embrace the study of the whole nature of man, and to have its ramifications among the kindred sciences of anatomy, physiology, chemistry, and others.

It presents a far wider field of study than ethnology, which relates either to the study of the history of nations or races individually, or in the comparison; and was first recognised by the British Association in the year 1846, when it was assigned a definite position as a sub-section of zoology under the presidency of the well-known Dr. Prichard. In 1851, for some reason or another, ethnology was united with geography in one section, but in 1866 this unnatural alliance ceased, and anthropology—so called for the first time—was replaced in its proper position in connexion with biology, and became a distinct department, with Mr. A. R. Wallace for its chairman. For eighteen years it continued in this subordinate condition, but in the year 1884 it was raised to the dignity of a separate section, which met for the first time at Montreal, with Dr. E. B. Tylor as its president.



SIR WM. TURNER,
M.B., LL.D., F.R.S.L. AND E.,
PRESIDENT-ELECT: SECTION H.
(Engraved from a photograph, by kind permission of Mr John Moffat, Edinburgh.)

It has been usual to divide the work of the section into three or four parts, all the papers on prehistoric anthropology or archæology being taken on one day, those on ethnology and ethnography on a second, those on physical anthropology on a third, whilst papers treating of sociology and kindred subjects would have a day to themselves.

This year it is proposed to devote one day to the discussion of the question of heredity, and it is hoped that many eminent anthropologists will be present on the occasion.

In few branches of science has so great advance been made during the last quarter of a century as in anthropology. When the British Association last met at Newcastle, in 1863, the very name was scarcely recognised, and the committee of section E (geography and ethnology) actually rejected papers simply because they were anthropological. Nevertheless, many anthropological papers were read, one of the most valuable of which, "On Cranial Deformities," was contributed by the distinguished anthropologist who will preside over the section this year, and who was then one of the secretaries of the physiological subsection of section D. We may attribute the rapid acknowledgment of the importance of anthropological science to the recognition of its capability of yielding practical results, and it is not to be wondered at that its intrinsic value was not appreciated while its chief object seemed to be to determine merely such questions as the unity or diversity of the origin of man.

Now, however, when departments of the science more fruitful in practical results are receiving attention, the study of man bids fair to enlist increased numbers of laborious workers as well as to become popular, and there are few sections that ought to furnish more subjects of general interest.

To the teacher of modern language the knowledge of the steps by which it developed from conversation by gesticulation must prove useful.

Those who are interested in labour questions will find in the study of the comparative powers of endurance shown in different nations and districts and the causes which give rise to the difference, a subject well worthy of their attention.

The man who is engaged in questions of military organisations and expeditions must to a certain extent be a student of the science of man; for if he were to ignore some of its facts, such as the transmission of bodily capacity to endure hardships, and the variability of the power to resist the effects of change of climate, he would neglect a very fertile field of useful information.

One of the most popular and at the same time most useful branches of this section is that which deals with the measurement of the human form and faculties; a widely-organised body of workers being all that is required to make this a most productive field of inquiry.

Anthropometry, as this branch has been called, would require State aid to carry it out properly. It is hardly too much to hope that before long an Anthropometric examination will be made of all children attending school as a regular thing each year. The information thus gained would be very valuable, while the expense would be comparatively small.

Parents would learn facts that had escaped them in regard to the physical developement of their children, and statistics would be gathered which would be of great scientific interest. If the employers of labour would carry out a systematic measurement of the form and faculties of the men in their employment, they would gain information useful to themselves, and furnish material for valuable statistics. At the Health Exhibition in London 10,000 people voluntarily had these various measurements made and recorded. The instruments were for the most part simple though ingenious, and a careful and accurate person would have no difficulty in using them correctly. Anthropology calls for a collection of facts that may be relied on.

It is somewhat embarrassing to feel the presence of a body of scientists in our midst who note our development, our features, and the acuteness of our faculties, and draw conclusions therefrom whence we have come, if not also whither we are going. The men and women of Northumberland and Durham have nothing to fear from comparison with the majority of their neighbours; and there are certainly no statistics to show that they are inferior either in physique or intelligence.

Perhaps at this meeting of the Association some one will be able to locate the origin of the Northern *burr*, which seems to be unaccounted for as yet.

Members of the Association can visit the laboratory in the Free Library at any time during the meeting, and every one who is examined is given a copy of the measurements taken.

The first grant made by the British Association for anthropological purposes was in 1841, when £5 was voted to a committee for investigating the races of men; a few years later a committee was appointed for ethnological inquiries, and received a grant of £12; in all, something over £3,000 has been spent by the association on anthropological investigation during the last 50 years.

The success of a section is frequently enhanced by its president, and the anthropological section in Newcastle has been more than fortunate in this respect. Sir William Turner, the eminent Professor of Anatomy in the University of Edinburgh, was born at Lancaster in the year 1832, and became a distinguished scholar under Sir James Paget at St. Bartholomew's Hospital. He obtained his membership of the Royal College of Surgeons in 1853, and in 1854 gained the Gold Medal of London University; in the same year he was appointed Senior Demonstrator of Anatomy at Edinburgh, and in 1857 he took the degree of M.B. of London. In 1867, Prof. Turner was elected to the chair which he now so ably fills, as the successor of the immortal Goodsir, and in 1886 he received the honour of knighthood in recognition of his services to the University of Edinburgh.

Sir Wm. Turner has at various times held important surgical and medical posts, and is president of the Royal College of Surgeons of Edinburgh, and a member of the General Medical Council; he is a Fellow of the Royal Societies of London and Edinburgh, Honorary LL.D. of Glasgow, and Professor of Anatomy to the Royal Scottish Academy.

When the British Association met at Edinburgh in the year 1871, Professor Turner presided over the department of anthropology, and in 1885, at Aberdeen, he was one of the vice-presidents of the section. He is the author of many works on the anatomy and histology of man and the lower animals, amongst which may be mentioned the Atlas of Human Anatomy and Physiology, the articles on anatomy, anthropotomy, and the digestive organs in the last edition of the "Encyclopædia Britannica," and the report on the whales and seals collected by H.M.S. Challenger. He also wrote the monographs on the human crania and other bones brought home by the "Challenger" expedition, a work which forms one of the most important contributions to anthropological literature that has ever appeared in England.

Sir William Turner has been an enthusiastic volunteer ever since the commencement of the movement in 1859, and now holds a commission as Major in the First Volunteer Battalion of the Royal Scots.

It may be mentioned as evidence of the healthy nature of anatomical and anthropological pursuits, that Sir William Turner has had only four predecessors in the chair of anatomy at Edinburgh, which was founded in the year 1720, no less than 169 years ago.

◆

THE PRESIDENT'S ADDRESS.

In the evening the new president, Professor Flower, delivered the presidential address in St. George's Hall, Newcastle. The hall was capable of holding the members of the Association who attended, for, although it was filled, with a few exceptions every one was able to procure a seat. The doors were opened at 7·15, and from that time there was a continuous stream of visitors, the majority of whom arrived in carriages. Promptly at eight o'clock the retiring president, Sir Frederick J. Bramwell, Bart., D.C.L., F.R.S., M.Inst.C.E., took the chair. A platform large enough to accommodate two or three hundred persons had been erected, and amongst those surrounding the chair were :—Lord Armstrong, the Mayor of Newcastle (Mr. T. Richardson), the Sheriff of Newcastle (Mr. W. Sutton), Sir John Lubbock, M.P. ; Prof. Cayley, Sir Douglas Galton (general secretary), the Right Hon. John Morley, M.P. ; Admiral Sir Erasmus Ommanney, C.B. ; Mr. Benjamin Baker, Capt. Abney, C.B. ; Sir Wm. Thornson, Sir Isaac Lowthian Bell, Bart.; Sir Francis de Winton, Professor James Geikie, Prof. Edgeworth, Mr. Wm. Anderson, Sir Wm. Turner, the Lord Bishop of Newcastle (Dr. Wilberforce), Mr. J. C. Stevenson, M.P., Mr. A. G. Vernon Harcourt (general secretary), Mr. A. T. Aitchison (secretary), Prof. J. H. Merivale, and Prof. P. P. Bedson (local hon. secretaries), Canon Tristram, Dr. Bruce, &c.

Sir Frederick J. Bramwell said : Ladies and gentlemen, it is inevitable that the president who is about to retire should be the man who probably knows the least of the science of the man who is about to succeed him ; because the object is that the various sections should be duly represented in the presidentship of the association, and thereupon it follows that we get contrasts, as it were, between the particular presidents. I, therefore, dare not attempt to speak to you of the works of my successor—Professor Flower. Moreover, it would be very unnecessary for me to do it, even if I had the ability to do it. I do not like works of supererogation, and I am quite certain no words are needed to introduce Professor Flower to the chair of the British Association. (Loud cheers.) I will only remind you that at the time of the Crimean War Professor Flower was one of the first to volunteer to go out there and to exercise his professional ability as a medical man, and that he did so in the full hardships of the early months of that undertaking. (Cheers.) On his return he became the conservator of the Museum of the Royal College of Surgeons, and there inaugurated a system of illustration of comparative anatomy of mammalia which, I believe, is of world-wide renown. (Cheers.) Then, as you know, he became that which he is now—the director of the Natural History branch of the British Museum, where, I am certain, everyone will appreciate the value of the labours he has bestowed upon that branch. (Cheers.) It only remains for me to vacate this chair, which I do with very much pleasure, in order to introduce to you as my successor Professor Flower, who is about to deliver to you an address which you will find, I have no doubt, is about something. (Laughter and cheers.)

The President then vacated the chair, and it was taken by Professor William Henry Flower, C.B., LL.D., F.R.S., F.R.C.S., Pres. Z.S., F.L.S., F.G.S., director of the Natural History Department of the British Museum, president-elect.

The President then delivered his inaugural address. He spoke as follows :—It is twenty-six years since this Association met in Newcastle-upon-Tyne. It had then the advantage of being presided over by one of the most distinguished and popular of your fellow-townsmen.

A LOCAL EX-PRESIDENT.

Considering the age usually attained by those upon whom the honour of the presidency falls, and the length of time which elapses before the association repeats its visit, it must have rarely happened that any one who has held the office is spared, not only to be present at another meeting in the town in which he has presided, but also to take such an active part in securing its success, and to extend such a hospitable welcome to his successor, as Lord Armstrong has done upon the present occasion. The address which was delivered at that meeting must have been full of interest to the great majority of those present. It treated of many subjects more or less familiar and important to the dwellers in this part of the world, and it treated them with the hand of a master, a combination which always secures the attention of an audience.

NEWCASTLE AND BIOLOGICAL SCIENCE.

When it came to my knowledge that in the selection of the president for this meeting the choice had fallen upon me, I was filled with apprehension. There was nothing in my previous occupations or studies from which I felt that I could evolve anything in special sympathy with what is universally recognised as the prevailing genius, of this district. I was, however, somewhat reassured when reminded that in the regular rotation by which the equal representation in the presidential office of the different branches of science included in the association is secured, the turn had come round for some one connected with biological subjects to occupy the chair, which during the past seven years has been filled with such distinction by engineers, chemists, physicists, mathematicians, and geologists. I was also reminded that the association, though of necessity holding its meeting in some definite locality, was by no means local in its character, but that its sphere was co-extensive, not with the United Kingdom only, but with the whole of the British dominions, and that our proceedings are followed with interest wherever our language is understood—I may say, throughout the civilised world. Furthermore, although its great manufacturing industries, the eminence of its citizens for their skill and intelligence in the practical application of mechanical sciences, and the interesting and important geological features of its vicinity, have conferred such fame on Newcastle, as almost to have overshadowed its other claims to distinction in connexion with science, this neighbourhood is also associated with Bewick, with Johnson, with Alder, Embleton, Hutton, Atthey, Norman, the two Hancocks, the two Bradys, and other names honoured in the annals of biology; it has long maintained a school of medicine of great repute; and there has lately been established here a natural history museum, which in some of its features is a model for institutions of the kind, and which, I trust, will be a means of encouraging in this town some of the objects the association was designed to promote.

MUSEUMS AND THE ADVANCEMENT OF SCIENCE.

There can be no doubt that among the various methods by which the aims of the British Association (as expressed in its full title, the advancement of science) may be brought about, the collection and preservation of objects available for examination, study, and reference—in fact, the formation of what are now called "museums"—is one of very great practical importance; so much so, indeed, that it seems to me one to the consideration of which it is desirable to devote some time upon such an occasion as this. It is a subject still little understood, though, fortunately, beginning to attract attention. It has already been brought before the notice of the association, both in presidential and sectional addresses. A committee of our members is at the present time engaged in collecting evidence upon it, and has issued some valuable reports. During the present year an association of curators and others interested in museums has been founded for the purpose of interchange of ideas upon the organisation and management of these institutions. It is a subject, moreover, if I may be allowed to mention a personal reason for bringing it forward this evening, which has more than any other occupied my time and my attention almost from the earliest period of my recollection, and I think you will agree with the opinion of one of my distinguished predecessors in this chair, "that the holder of this office will generally do better by giving utterance to what has already become part of his own thought than by gathering matter outside of its habitual range for the special occasion. For," continued Mr. Spottiswoode, "the interest (if any) of an address consists not so much in the multitude of things therein brought forward, as in the individuality of the mode in which they are treated."

THE FIRST MUSEUMS.

The first recorded institution which bore the name of museum, or temple or haunt of the Muses, was that founded by Ptolemy Soter at Alexandria about 300 B.C.; but this was not a museum in our sense of the word, but rather, in accordance with its etymology, a place appropriated to the cultivation of learning, or which was frequented by a society or academy of learned men devoting themselves to philosophical studies and the improvement of knowledge. Although certain great monarchs, as Solomon of Jerusalem and Augustus of Rome, displayed their taste and their magnificence by assembling together in their palaces curious objects brought from distant parts of the world—although it is said that the liberality of Philip and Alexander supplied Aristotle with abundant materials for his researches—of the existence of any permanent or public collections of natural objects among the ancients there is no record. Perhaps the nearest approach to such collections may be found in the preservation of remarkable specimens, sometimes associated with superstitious veneration, sometimes with strange legendary stories, in the buildings devoted to religious worship. The skins of the gorillas brought by the navigator Hanno from the West Coast of Africa, and hung up in the temple at Carthage, afford a well-known instance.

MEDIÆVAL MUSEUMS.

With the revival of learning in the middle ages, the collecting instinct, inborn in so many persons of various nations and periods of history, but so long in complete abeyance, sprang into existence with considerable vigour, and a museum, now meaning a collection of miscellaneous objects, antiquities as well as natural curiosities, often associated with a gallery of sculpture and painting, became a fashionable appendage to the establishment of many wealthy persons of superior culture. All the earliest collections, comparable to what we call museums, were formed by and maintained at the expense of private individuals; sometimes physicians, whose studies naturally led them to a taste for biological science; often great merchant princes, whose trading connexions afforded opportunities for bringing together things that were considered curious from foreign lands; or ruling monarchs in their private capacity. In every case they were maintained mainly for the gratification of the possessor or his personal friends, and rarely, if ever, associated with any systematic teaching or public benefit.

AN EARLY CATALOGUE.

One of the earliest known printed catalogues of such a museum is that of Samuel Quickelberg, a physician of Amsterdam, published in 1565 in Munich. In the same year Conrad Gesner published a catalogue of the collection of Johann Kentmann, a physician of Torgau in Saxony, consisting of about 1,600 objects, chiefly minerals, shells, and marine animals. Very soon afterwards we find the Emperor Rudolph II. of Germany busily accumulating treasures which constituted the foundations of the present magnificent museums by which the Austrian capital is distinguished.

EARLY ENGLISH MUSEUMS.

In England the earliest important collectors of miscellaneous objects were the two John Tradescants, father and son, the latter of whom published, in 1656, a little work called "Musæum Tradescantianum; or, a Collection of Rarities preserved at South Lambeth neer London." The wonderful variety and incongruous juxtaposition of the objects contained in this collection make the catalogue very amusing reading. Under the first division, devoted to "Some Kindes of Birds, their Egges, Beaks, Feathers, Clawes and Spurres," we find "Divers sorts of Egges from Turkie, one given for a Dragon's Egge"; "Easter Egges of the Patriarch of Jerusalem"; "Two Feathers of the Phœnix Tayle"; "The Claw of the bird Rock, who, as authors report, is able to trusse an elephant." Among "whole birds" is the famous "dodar from the Island Mauritius; it is not able to flie, being so big." This is the identical specimen, the head and foot of which has passed through the Ashmolean into the University Museum of Oxford; but we know not what has become of the claw of the rock, the phœnix tayle, and the dragon's egg. Time does not allow me to mention the wonderful things which occur under the head of "Garments, Vestures, Habits, and Ornaments," or the "Mechanick, Artificial Workes in Carvings, Turnings, Sowings, and Paintings," from Edward the Confessor's knit gloves and the famous "Pohatan, king of Virginia's habit, all embroidered with shells or roanoke," also still at Oxford, and lately figured and described by Mr. E. B. Tylor, to the "Cherry-stone, upon one side S. George and the Dragon, perfectly cut, and on the other side 88 Emperours' faces"; or the other "cherry-stone, holding ten dozen of tortoise-shell combs made by Edward Gibbons." But before leaving these private collections I cannot forbear mentioning, as an example of the great aid they often were in advancing science, the indebtedness of Linnæus in his early studies to the valuable zoological museums, which it was one of the ruling passions of several kings and queens of Sweden to bring together. Upon the association of individuals together into societies to promote the advancement of knowledge, these bodies in their corporate capacity frequently made the formation of a museum part of their function. The earliest instance of this in our country was the museum of the Royal Society in Crane Court, of which an illustrated catalogue was published by Dr. Grew in 1681.

UNIVERSITY COLLECTIONS.

The idea that the maintenance of a museum was a portion of the public duty of the State or of any municipal institution had, however, nowhere entered into the mind of man at the beginning of the last century. Even the great teaching bodies, the Universities, were slow in acquiring collections; but it must be recollected that the subjects considered most essential to the education they then professed to give were not those which needed illustration from the objects which can be brought together in a museum. The Italian Universities, where anatomy was taught as a science earlier and more thoroughly than anywhere else in Europe, soon found the desirability of keeping collections of preserved specimens, and the art of preparing them attained a high degree of excellence at Padua and Bologna two centuries ago. But these were generally the private property of the professors, as were nearly all the collections used to illustrate the teaching of anatomy and pathology in our country within the memory of many now living.

PUBLIC AND PRIVATE MUSEUMS.

Notwithstanding the multiplication of public museums during the present century, and the greater resources and advantages which many of these possess, which private collectors cannot command, the spirit of accumulation in individuals has happily not passed away, although usually directed into rather different channels than formerly. The general museums or miscellaneous collections of old are now left to governments and institutions which afford greater guarantee of their permanence and public utility, while admirable service is done to science by those private persons with leisure and means who, devoting themselves to some special subject, amass the materials by which its study can be pursued in detail either by themselves or by those they know to be qualified to do so; which collections, if they fulfil their most appropriate destiny, ultimately become incorporated, by gift or purchase, in one or other of the public museums, and then serve as permanent factors in the education of the nation, or rather of the world.

THEIR GENERAL VALUE.

It would be passing beyond the limits of time allotted to this address, indeed going beyond the scope of the Association, if I were to speak of many of the subjects which have pre-eminently exercised the faculties of the collector and formed the materials of which museums are constructed. The various methods by which the mind of man has been able to reproduce the forms of natural objects or to give expression to the images created by his own fancy, from rudest scratchings of a savage on a bone, or the simplest arrangement of lines employed in ornamenting the roughest piece of pottery, up to the most lovely combinations of form and colour hitherto attained in sculpture or in painting, or in works in metal or in clay, depend altogether on museums for their preservation, for our knowledge of their condition and history in the past, and for the lessons which they can convey for the future. Apart from the delight which the contemplation of the noblest expressions of art must produce in all cultivated minds, apart also from the curiosity and interest that must be excited by all the less successfully-executed attempts to produce similar results, as materials for constructing the true history of the life of man, at different stages of civilisation, in different circumstances of living, and in divers regions of the earth, such collections are absolutely invaluable.

NATURAL HISTORY MUSEUMS.

But I must pass them by in order to dwell more in detail upon those which specially concern the advancement of the subjects which come under the notice of this association—museums devoted to the so-called "natural history" sciences, although much will be said of them will doubtless be more or less applicable to museums in general. The terms "natural history" and "naturalist" have become deeply rooted in our language, but without any definite conception of their meaning or the scope of their application. Originally applied to the study of all the phenomena of the universe which are independent of the agency of man, natural history has gradually narrowed down in most people's minds, in consequence of the invention of convenient and generally understood and accepted terms for some of its various sub-divisions, as astronomy, chemistry, geology, &c., into that portion of the subject which treats of the history of creatures endowed with life, for which, until lately, no special name had been invented. Even from this limitation botany was gradually dissociating itself in many quarters, and a "naturalist" and a "zoologist" have nearly become, however irrationally, synonymous terms. The happy introduction and general acceptance of the word "biology," notwithstanding the objections raised to its etymological signification, have reunited the study of organisms distinguished by the possession of the living principle, and practically eliminated the now vague and indefinite term "natural history" from scientific terminology. As, however, it is certain to maintain its hold in popular language, I would venture to suggest the desirability of restoring it to its original and really definite signification, contrasting it with the history of man and of his works, and of the changes which have been wrought in the universe by his intervention.

THE DIVISION OF THE BLOOMSBURY COLLECTION.

It was in this sense that, when the rapid growth of the miscellaneous collections in the British Museum at Bloomsbury (the expansion of Sir Hans Sloane's accumulation in the old Manor House at Chelsea) was thought to render a division necessary, the line of severance was effected at the junction of what was natural and what was artificial; the former, including the products of what are commonly called "natural" forces, unaffected by man's handiwork, or the impress of his mind. The departments which took cognisance of these were termed the "Natural History Departments," and the new building to which they were removed the "Natural History Museum." It may be worth while to spend a few moments upon the consideration of the value of this division, as it is one which concerns the arrangement and administration of 'the majority of museums. Though there is very much to be said for it, the objection has been raised that it cuts man himself in two. The illustrations of man's bodily structure are undoubtedly subjects for the zoologist. The subtile gradations of form, proportion, and colour which distinguish the different races of men, can only be appreciated by one with the education of an anatomist, and whose eye has been trained to estimate the value of such characters in discriminating the variations of animal forms. The subjects for comparison required for this branch of research must therefore be looked for in the zoological collections. But the comparatively new science of "anthropology" embraces not only man's physical structure: it includes his mental development, his manners, customs, traditions, and languages. The illustrations of his works of art, domestic utensils, and weapons of war are essential parts of its study. In fact it is impossible to say where it ends. It includes all that man is or ever has been, all that he has ever done. No definite line can be drawn between the rudest flint weapon and the most exquisitely finished instrument of destruction which has ever been turned out from the manufactory at Elswick, between the rough representation of a mammoth, carved by one of its contemporary men on a portion of its own tusk, and the most admirable production of a Landseer. An anthropological collection, to be logical, must include all that is in not only the old British Museum but the South Kensington Museum and the National Gallery. The notion of an anthropology which considers savages and pre-historic people as apart from the rest of mankind may, in the limitations of human powers, have certain conveniences, but it is utterly unscientific and loses sight of the great value of the study in tracing the gradual growth of our complex systems and customs from the primitive ways of our progenitors. On the other hand, the division first indicated is as perfectly definite, logical, and scientific as any such division can be. That there are many inconveniences attending wide local disjunctions of the collections containing subjects so distinct yet so nearly allied as physical and psychical anthropology must be fully admitted; but these could only have been overcome by embracing in one grand institution the various national collections illustrating the different branches of science and art, placed in such order and juxtaposition that their mutual relations might be apparent, and the resources of each might be brought to bear upon the elucidation of all the others—an ideal institution, such as the world has not yet seen, but into which the old British Museum might at one time have been developed.

WHAT A NATURAL HISTORY MUSEUM SHOULD BE.

A purely "Natural History Museum" will then embrace a collection of objects illustrating the natural productions of the earth, and in its widest and truest sense should include, as far as they can be illustrated by museum specimens, all the sciences which deal with natural phenomena. It has only been the difficulties, real or imaginary, in illustrating them which have excluded such subjects as astronomy, physics, chemistry, and physiology from occupying departments in our National Natural History Museum, while allowing the introduction of their sister sciences, mineralogy, geology, botany, and zoology.

EXPERIMENTAL SCIENCE EXHIBITIONS.

Though the experimental sciences and those which deal with the laws which govern the universe, rather than with the materials of which it is composed, have not hitherto greatly called forth the collector's instinct, or depended upon museums for their illustration, yet the great advantages of collections of the various instruments by means of which these sciences are pursued, and of examples of the methods by which they are taught, are yearly becoming more manifest. Museums of scientific apparatus now form portions of every well-equipped educational establishment, and under the auspices of the Science and Art Department at South Kensington a national collection illustrating those branches of natural history science which have escaped recognition in the British Museum is assuming a magnitude and importance which brings the question of properly housing and displaying it urgently to the front.

INEVITABLE ANOMALIES.

Anomalies such as these are certain to occur in the present almost infantile though rapidly progressive state of science. It may be taken for granted that no scientific institution of any complexity of organisation can be, except at the moment of its birth, abreast of the most modern views of the subject, especially in the dividing lines between, and the proportional representation of, the various branches of knowledge which it includes.

THE SUB-DIVISION OF SCIENCE AND ITS EFFECTS ON MUSEUMS.

The necessity for subdivisions in the study of science is continually becoming more apparent as the knowledge of the details of each subject multiplies without corresponding increase in the power of the human mind to grasp and deal with them, and the dividing lines not only become sharper, but as knowledge advances they frequently require revision. It might be supposed that such revision would adjust itself to the direction taken by the natural development of the relations of the different branches of science, and the truer conceptions entertained of such relations. But this is not always so. Artificial barriers are continually being raised to keep these dividing lines in the direction in which they have once started. Difficulties of readjustment arise not only from the mechanical obstacles caused by the size and arrangements of the buildings and facilities for the allocation of various kinds of collections, but still more from the numerous personal interests which grow up and wind their meshes around such institutions. Professorships and curatorships of this or that division of science are founded and endowed, and their holders are usually tenacious either of encroachment upon or of any wide enlargement of the boundaries of the subject they have undertaken to teach or to illustrate; and in this way, more than any other, passing phases of scientific knowledge have become crystallised or fossilised in institutions where they might least have been expected. I may instance many European universities and great museums in which zoology and comparative anatomy are still held to be distinct subjects taught by different professors, and where, in consequence of the division of the collections under their charge, the skin of an animal, illustrating its zoology, and its skeleton and teeth, illustrating its anatomy, must be looked for in different and perhaps remotely placed buildings. For the perpetuation of the unfortunate separation of palæontology from biology, which is so clearly a survival of an ancient condition of scientific culture, and for the maintenance in its integrity of the heterogeneous compound of sciences which we now call "geology," the faulty organisation of our museums is in a great measure responsible. The more their re-arrangement can be made to overstep and break down the abrupt line of demarcation which is still almost universally drawn between beings which live now and those which have lived in past times, so deeply rooted in the popular mind and so hard to eradicate even in that of the scientific student, the better it will be for the progress of sound biological knowledge.

MINOR DEFECTS AND THEIR REMEDIES.

But it is not of the removal of such great anomalies and inconsistencies which, when they have once grown up, require heroic methods to set them right, but rather of certain minor defects in the organisation of almost all existing museums which are well within the capacity of comparatively modest administrative means to remedy, that I have now to speak. That great improvements have been lately effected in many respects in some of the museums in this country, on the Continent, and especially in America, no one can deny. The subject, as I have already indicated, is, happily, exciting the attention of those who have the direction of them, and even awakening interest in the mind of the general public. It is in the hope of in some measure helping on or guiding this movement that I have ventured on the remarks which follow.

WHAT CONSTITUTES A SUCCESSFUL MUSEUM.

The first consideration in establishing a museum, large or small, either in a town, institution, society, or school, is that it should have some definite object or purpose to fulfil; and the next is that means should be forthcoming not only to establish but also to maintain the museum in a suitable manner to fulfil that purpose. Some persons are enthusiastic enough to think that a museum is in itself so good an object that they have only to provide a building and cases and a certain number of specimens, no matter exactly what, to fill them and then the thing is done; whereas the truth is the work has only then begun.

IMPORTANCE OF THE CURATOR.

What a museum really depends upon for its success and usefulness is not its building, not its cases, not even its specimens, but its curator. He and his staff are the life and soul of the institution, upon whom its whole value depends; and yet in many—I may say most of our museums—they are the last to be thought of. The care, the preservation, the naming of the specimens are either left to voluntary effort—excellent often for special collections and for a limited time, but never to be depended on as a permanent arrangement — or a grievously undersalaried and consequently uneducated official is expected to keep in order, to clean, dust, arrange, name, and display in a manner which will contribute to the advancement of scientific knowledge, collections ranging in extent over almost every branch of human learning, from the contents of an ancient British barrow to the last discovered bird of paradise from New Guinea. Valuable specimens not unfrequently find their way into museums thus managed. Their public-spirited owners fondly imagine that they will be preserved and made of use to the world if once given to such an institution. Their fate is, unfortunately, far otherwise. Dirty, neglected, without label, their identity lost, they are often finally devoured by insects or cleared away to make room on the crowded shelves for the new donation of some fresh patron of the institution. It would be far better that such museums should never be founded. They are traps into which precious—sometimes priceless—objects fall only to be destroyed; and, what is still worse, they bring discredit on all similar institutions, make the very name of museum a byword and a reproach, hindering instead of advancing the recognition of their value as agents in the great educational movement of the age. A museum is like a living organism—it requires continual and tender care. It must grow, or it will perish; and the cost and labour required to maintain it in a state of vitality is not yet by any means fully realised or provided for, either in our great national establishments or in our smaller local institutions.

REAL OBJECTS OF COLLECTORS.

Often as it has been said, it cannot be too often repeated that the real objects of forming collections, of whatever kind (apart, of course, from the mere pleasure of acquisition—sometimes the only motive of private collectors), and which, although in very different degrees, and often without being recognised, underlie the organisation of all museums, are two, which are quite distinct, and sometimes even conflicting. The first is to advance or increase the knowledge of some given subject. This is generally the motive of the individual collector, whose experience shows him the vast assistance in forming definite ideas in any line of research in which he may be occupied that may be derived from having the materials for its study at his own command, to hold and to handle, to examine and compare, to take up and lay aside whenever the favourable moment to do so occurs. But unless his subject is a very limited one, or his means the reverse, he soon finds the necessity of consulting collections based on a larger scale than his own. Very few people have any idea of the multiplicity of specimens required for the purpose of working out many of the simplest problems concerning the life-history of animals or plants. The naturalist has frequently to ransack all the museums, both public and private, of Europe and America in the endeavour to compose a monograph of a single common genus, or even species, that shall include all questions of its variation, changes in different seasons, and under different climates and conditions of existence, and the distribution in space and time of all its modifications. He often has to confess at the end that he has been baffled in his research for want of the requisite materials for such an undertaking. Of course, this ought not to be, and the time will come when it will not be, but that time is very far off yet. We all know the old saying that the craving for riches grows as the wealth itself increases. Something similar is true of scientific collections brought together for the purpose of advancing knowledge. The larger they are, the more their deficiencies seem to become conspicuous; the more desirous we are to fill up the gaps which provokingly interfere with our extracting from them the complete story they have to tell. Such collections are, however, only for the advanced student, the man who has already become acquainted with the elements of his science, and is in a position, by his knowledge, by his training, and by his observing and reasoning capacity, to take advantage of such material to carry on the subject to a point beyond that at which he takes it up. But there is another and far larger class to whom museums are or should be a powerful means of aid in acquiring knowledge. Among such, those who are commencing more serious studies may be included; but I especially refer to the much more numerous class, and one which it may be hoped will year by year beargreater a relative proportion to the general population of the country, who, without having the time, the opportunities, or the abilities to make a profound study of any branch of science, yet take a general interest in its progress, and wish to possess some knowledge of the world around them and of the principal facts ascertained with regard to it, or at least some portions of it. For such persons museums may be, when well organised and arranged, of benefit to a degree that at present can scarcely be realised. To diffuse knowledge among persons of this class is the second of the two purposes of museums of which I have spoken.

THE CAUSE OF FAILURE.

I believe that the main cause of what may be fairly termed the failure of the majority of museums—especially museums of natural history—to perform the functions that might be legitimately expected of them is that they nearly always confound together the two distinct objects which they may fulfil, and by attempting to combine both in the same exhibition practically accomplish neither. In accordance with which of those two objects, which may be briefly called *research* and *instruction*, is the main end of the museum, so should the whole be primarily arranged; and in accordance with the object for which each specimen is required, so should it be treated.

RESEARCH MUSEUMS.

The specimens kept for research, for advancement of knowledge, for careful investigations in structure and development, or for showing the minute distinctions which must be studied in working out the problems connected with variations of species according to age, sex, season, or locality; for fixing the limits of geographical distribution, or determining the range in geological time, must be not only exceedingly numerous (so numerous, indeed, that it is almost impossible to put a limit on what may be required for such purposes), but they must also be kept under such conditions as to admit of ready and close examination and comparison. If the whole of the specimens really required for enlarging the boundaries of zoological or botanical science were to be displayed in such a manner that each one could be distinctly seen by any visitor sauntering through the public galleries of a museum, the vastness and expense of the institution would be out of all proportion to its utility; the specimens themselves would be quite inaccessible to the examination of all those capable of deriving instruction from them, and, owing to the injurious effects of continued exposure to light upon the greater number of preserved natural objects, would ultimately lose a large part of their permanent value. Collections of this kind must, in fact, be treated as the books in a library, and be used only for consultation and reference by those who are able to read and appreciate their contents. To demand, as has been ignorantly done, that all the specimens belonging to our national museums, for instance, should be displayed in cases in the public galleries would be equivalent to asking that every book in a library, instead of being shut up and arranged on shelves for consultation when required, should have every single page framed and glazed and hung on the walls, so that the humblest visitor as he passes along the galleries has only to open his eyes and revel in the wealth of literature of all ages and all countries, without so much as applying to a custodian to open a case. Such an arrangement is perfectly conceivable. The idea from some points of view is magnificent, almost sublime. But imagine the space required for such an arrangement of the national library of books, or, indeed, of any of the smallest local libraries; imagine the inconvenience to the real student, the disadvantages which he would be under in reading the pages of any work fixed in an immovable position beneath a glass case; think of the enormous distances he would often have to traverse to compare a reference or verify a quotation, and the idea of sublimity soon gives place to its usual antithesis. The attempt to display every bird, every insect, shell, or plant which is or ought to be in any of our great museums of reference would produce an exactly similar result.

HOW THEY SHOULD BE ARRANGED.

In the arrangement of collections designed for research, which, of course, will contain all those precious specimens called "types," which must be appealed to through all time to determine the species to which a name was originally given, the principal points to be aimed at are—the preservation of the objects from all ininfluences deleterious to them, especially dust, light, and damp; their absolutely correct identification, and record of every circumstance that need be known of their history; their classification and storage in such a manner that each one can be found without difficulty or loss of time; and, both on account of expense as well as convenience of access, they should be made to occupy as small a space as is compatible with these requirements. They should be kept in rooms provided with suitable tables and good light for their examination, and within reach of the necessary books of reference on the particular subjects which the specimens illustrate. Furthermore, the rooms should be so situated that the officers of the museum, without too great hindrance to their own work, can be at hand for occasional assistance and supervision of the student, and if collections of research and exhibited specimens are contained in one building, it is obvious that the closer the contiguity in which those of any particular group are placed the greater will be the convenience both of students and curators, for in very few establishments will it be possible to form each series on such a scale as to be entirely independent of the other.

INSTRUCTION MUSEUMS.

On the other hand, in a collection arranged for the instruction of the general visitor, the conditions under which the specimens are kept should be totally different. In the first place, their numbers must be strictly limited, according to the nature of the subject to be illustrated and the space available. None must be placed too high or too low for ready examination. There must be no crowding of specimens one behind the other, every one being perfectly and distinctly seen, and with a clear space around it. Imagine a picture gallery with half the pictures on the walls partially or entirely concealed by others hung in front of them; the idea seems preposterous, and yet this is the approved arrangement of specimens in most public museums. If an object is worth putting into a gallery at all it is worth such a position as will enable it to be seen. Every specimen exhibited should be good of its kind, and all available skill and care should be spent upon its preservation and rendering it capable of teaching the lesson it is intended to convey. And here I cannot refrain from saying a word upon the sadly neglected art of taxidermy, which continues to fill the cases of most of our museums with wretched and repulsive caricatures of mammals and birds, out of all natural proportions, shrunken here and bloated there, and in attitudes absolutely impossible for the creature to have assumed while alive. Happily there may be seen occasionally, especially where amateurs of artistic taste and good knowledge of natural history have devoted themselves to the subject, examples enough—and you are fortunate in possessing them in Newcastle—to show that an animal can be converted after death, by a proper application of taxidermy, into a real life-like representation of the original, perfect in form, proportions, and attitude, and almost, if not quite, as valuable for conveying information on these points as the living creature itself. The fact is that taxidermy is an art resembling that of the painter, or rather the sculptor; it requires natural genius as well as great cultivation, and it can never be permanently improved until we have abandoned the present conventional low standard and low payment for "bird stuffing," which is utterly inadequate to induce any man of capacity to devote himself to it as a profession. To return from this digression, every specimen exhibited should have its definite purpose, and no absolute duplicate should on any account be permitted. Above all, the purpose for which each specimen is exhibited, and the main lesson to be derived from it, must be distinctly indicated by the labels affixed, both as headings of the various divisions of the series, and to the individual specimens. A well-arranged educational museum has been defined as a collection of instructive labels illustrated by well-selected specimens.

MANAGEMENT OF PUBLIC MUSEUMS.

What is, or should be, the order of events in arranging a portion of a public museum? Not, certainly, as too often happens now, bringing a number of specimens together almost by haphazard, and cramming them as closely as possible in a case far too small to hold them, and with little reference to their order or to the possibility of their being distinctly seen. First, as I said before, you must have your curator. He must carefully consider the object of the museum, the class and capacities of the persons for whose instruction it is founded, and the space available to carry out this object. He will then divide the subject to be illustrated into groups, and consider their relative proportions, according to which he will plan out the space. Large labels will next be prepared for the principal headings, as the chapters of a book, and smaller ones for the various sub-divisions. Certain propositions to be illustrated, either in the structure, classification, geographical distribution, geological position, habits, or evolution of the subjects dealt with, will be laid down and reduced to definite and concise language. Lastly will come the illustrative specimens, each of which as procured and prepared will fall into its appropriate place. As it is not always easy to obtain these at the time they are wanted, gaps will often have to be left, but these, if properly utilised by drawings or labels, may be made nearly as useful as if occupied by the actual specimens. A public exhibition which is intended to be instructive and interesting must never be crowded. There is, indeed, no reason why it ever should be. Every such exhibition, whether on a large or small scale, can only contain a representative series of specimens, selected with a view to the needs of the particular class of persons who are likely to visit the gallery, and the number of specimens exhibited should be adapted to the space available. There is, therefore, rarely any excuse for filling it up in such a manner as to interfere with the full view of every specimen shown. A crowded gallery, except in some very exceptional circumstances, at once condemns the curator, as the remedy is generally in his own hands. In order to avoid it he has nothing to do but sternly to eliminate all the less important specimens. If any of these possess features of historical or scientific interest demanding their permanent preservation, they should be kept in the reserve collections; if otherwise, they should not be kept at all.

IDEAL ARRANGEMENTS.

The ideal public museums of the future will, however, require far more exhibition space than has hitherto been allowed; for though the number of specimens shown may be fewer than is often thought necessary now, each will require more room if the conditions above described are carried out, and especially if it is thought desirable to show it in such a manner as to enable the visitor to realise something of the wonderful complexity of the adaptations which bring each species into harmonious relation with its surrounding conditions. Artistic reproductions of natural environments, illustrations of protective resemblances, or of special modes of life, all require much room for their display. This method of exhibition, wherever faithfully carried out, is, however, proving both instructive and attractive, and will doubtless be greatly extended.

GUIDE-BOOKS AND CATALOGUES.

Guide-books and catalogues are useful adjuncts, as being adapted to convey fuller information than labels, and as they can be taken away for study during the intervals of visits to the museum, but they can never supersede the use of labels. Any one who is in the habit of visiting picture-galleries where the names of the artists and the subject are affixed to the frame, and others in which the information has in each case to be sought by reference to a catalogue, must appreciate the vast superiority in comfort and time-saving of the former plan. Acting upon such principles as these, every public gallery of a museum, whether the splendid saloon of a national institution or the humble room containing the local collection of a village club, can be made a centre of instruction, and will offer interests and attractions which will be looked for in vain in the majority of such institutions at the present time.

GOOD ILLUSTRATIONS.

One of the best illustrations of the different treatment of collections intended for research or advancement of knowledge, and for popular instruction or diffusion of knowledge, is now to be seen in Kew Gardens, where the admirably constructed and arranged herbarium answers the first purpose, and the public museums of economic botany the second. A similar distinction is carried out in the collections of systematic botany in the natural history branch of the British Museum, with the additional advantage of close contiguity; indeed, as an example of a scheme of good museum arrangement (although not perfect yet in details) I cannot do better than refer to the upper storey of the east wing of that institution. The same principle, little regarded in former times in this country, and still unknown in some of the largest Continental museums, are gradually pervading every department of the institution, which, from its national character, its metropolitan position, and exceptional resources ought to illustrate in perfection the ideal of a natural history museum. In fact, it is only in a national institution that an exhaustive research collection in all branches of natural history, in which the specialist of every group can find his own subject fully illustrated, can or ought to be attempted.

BENEFITS OF CENTRALISATION.

As the actual comparison of specimen with specimen is the basis of zoological and botanical research, and as work done with imperfect materials is necessarily imperfect in itself, it is far the wisest policy to concentrate in a few great central institutions, the number and situation of which must be determined by the population and the resources of the country, all the collections, especially those containing specimens already alluded to as so dear to the systematic naturalist known as author's "types," required for original investigations. It is far more advantageous to the investigator to go to such a collection and take up his temporary abode there, while his research is being carried out, with all the material required at his hand at once, than to travel from place to place and pick up piecemeal the information he requires, without opportunity of direct comparison of specimens. I do not say that collections for special study, and even original research, should not, under particular circumstances and limitations, be formed at museums other than central national institutions, or that nothing should be retained in provincial museums but what is of a directly educational or elementary nature. A local collection, illustrating the fauna and flora of the district, should be part of every such museum; and this may be carried to almost any amount of detail, and therefore in many cases it would be very unadvisable to exhibit the whole of it. A selection of the most important objects may be shown under the conditions described above, and the remainder carefully preserved in cabinets for the study of specialists.

COMMON OBJECTS.

It is also very desirable in all museums, in order that the exhibited series should be as little disturbed as possible in arrangement, and be always available for the purpose for which it is intended, that there should be, for the use of teachers and students, a supplementary set of common objects, which, if injured, could be easily replaced. It must not be forgotten that the zealous investigator and the conscientious curator are often the direst antagonists: the one endeavours to get all the knowledge he can out of a specimen, regardless of its ultimate fate, and even if his own eyes alone have the advantage of it; the other is content if a limited portion only is seen, provided that can be seen by every one both now and hereafter.

THE PRIMARY PRINCIPLE SUMMARISED.

Such, then, is the primary principle which ought to underlie the arrangement of all museums—the distinct separation of the two objects for which collections are made; the publicly exhibited collection being never a store-room or magazine, but only such as the ordinary visitor can understand and profit by, and the collection for students being so arranged as to afford every facility for examination and research. The improvements that can be made in detail in both departments are endless, and to enter further into their consideration would lead me far beyond the limits of this address. Happily, as I said before, the subject is receiving much attention.

EVOLUTION.

I would willingly dwell longer upon it—indeed I feel that I have only been able to touch slightly and superficially upon many questions of practical interest, well worthy of more detailed consideration—but time warns me that I must be bringing this discourse to a close, and I have still said nothing in reference to subjects upon which you may expect some words on this occasion. I mean those great problems concerning the laws which regulate the evolutions of organic beings, problems which agitate the minds of all biologists of the present day, and the solution of which is watched with keen interest by a far wider circle—a circle, in fact, coincident with the intelligence and education of the world. Several communications connected with these problems will be brought before the sectional meetings during the next few days, and we shall have the advantage of hearing them discussed by some of those who, by virtue of their special attention to and full knowledge of these subjects, are most competent to speak with authority. It is, therefore, for me rather delicate ground to tread upon, especially at the close of a discourse mainly devoted to another question. I will, however, briefly point out the nature of the problems and the lines which the endeavour to solve them will probably take, without attempting to anticipate the details, which you will doubtless hear most fully and ably stated elsewhere. I think I may safely premise that few, if any, original workers at any branch of biology appear now to entertain serious doubt about the general truth of the doctrine that all existing forms of life have been derived from other forms by a natural process of descent with modification, and it is generally acknowledged that to the records of the past history of life upon the earth we must look for the actual confirmation of the truth of a doctrine which accords so strongly with all we know of the present history of living beings.

THE EVIDENCE OF PALÆONTOLOGY.

Professor Huxley wrote in 1875:—"The only perfectly safe foundation for the doctrine of evolution lies in the historical, or rather archæological, evidence that particular organisms have arisen by the gradual modification of their predecessors, which is furnished by fossil remains. That evidence is daily increasing in amount and in weight, and it is to be hoped that the comparisons of the actual pedigree of these organisms with the phenomena of their development may furnish some criterion by which the validity of phylogenic conclusions, deduced from the facts of embryology alone may be satisfactorily tested." Palæontology, however, as we all know, reveals her secrets with no open hand. How can we be reminded of this more forcibly than by the discovery announced scarcely three months ago by Professor Marsh of numerous mammalian remains from formations of the Cretaceous period, the absence of which had so long been a source of difficulty to all zoologists? What vistas does this discovery open of future possibilities, and what thorough discredit, if any were needed, does it throw on the value of negative evidence in such matters! Bearing fully in mind the necessary imperfection of the record we have to deal with, I think that no one taking an impartial survey of the recent progress of palæontological discovery can doubt that the evidence in favour of a gradual modification of living forms is still steadily increasing. Any regular progressive series of changes of structure coinciding with changes in time can of course only be expected to be preserved and to come again before our eyes under such a favourable combination of circumstances as must be of most rare occurrence; but links, more or less perfect, of many such series are continually being revealed, and the discovery of a single intermediate form is often of immense interest as indicating the path along which the modification from one apparently distinct form to another may have taken place.

IMPORTANT NEW WORKS.

Though palæontology may be appealed to in support of the conclusion that modifications have taken place as time advanced, it can scarcely afford any help in solving the more difficult problems which still remain as to the methods by which the changes have been brought about. Ever since the publication of what has been truly described as the "creation of modern natural history," Darwin's work on the "Origin of Species," there has been no little controversy as to how far all the modifications of living forms can be accounted for by the principle of natural selection or preservation of variations best adapted for their surrounding conditions, or whether any, and if so what, other factors have taken part in the process of organic evolution. It certainly cannot be said that in these later times the controversy has ended. Indeed those who are acquainted with scientific literature must know that notes struck at the last annual meeting of this Association produced a series of reverberations, the echoes of which have hardly yet died away. Within the last few months also two important works have appeared in our country, which have placed in an accessible and popular form many of the data upon which the most prevalent views on the subject are based. The first is "Darwinism: An Exposition of the Theory of Natural Selection, with some of its Applications," by Alfred Russel Wallace. No one could be found so competent to give such an exposition of the theory as one who was, simultaneously with Darwin, its independent originator, but who, by the title he has chosen no less than by the contents of the book, has, with rare modesty and self-abnegation, transferred to his fellow-labourer all the merit of the discovery of what he evidently looks upon as a principle of overwhelming importance in the economy of nature; "supreme," indeed, he says, "to an extent which even Darwin himself hesitated to claim for it." The other work I refer to is the English translation of the remarkable "Essays upon Heredity and Kindred Biological Problems," by Dr. August Weismann, published at the Oxford Clarendon Press, in which is fully discussed the very important but still open question—a question which was brought into prominence at our meeting at Manchester two years ago—of the transmission or non-transmission to the offspring of characters acquired during the lifetime of the parent.

AGENCIES OF MODIFICATION.

It is generally recognised that it is one of the main elements of Darwin's, as well as of every other theory of evolution, that there is in every individual organic being an innate tendency to vary from the standard of its predecessors, but that this tendency is usually kept under the sternest control by the opposite tendency to resemble them, a force to which the terms "heredity" and "atavism" are applied. The causes of this initial tendency to vary, as well as those of its limits and prevailing direction, and the circumstances which favour its occasional bursting through the constraining principle of heredity offer an endless field for speculation. Though several theories of variation have been suggested, I think that no one would venture to say we have passed beyond the threshold of knowledge of the subject at present. Taking for granted, however, as we all do, that this tendency to individual variation exists, then comes the question, What are the agents by which, when it has asserted itself, it is controlled or directed in such a manner as to produce the permanent or apparently permanent modifications of organic structures which we see around us? Is "survival of the fittest" or preservation by natural selection of those variations best adapted for their surrounding conditions (the essentially Darwinian or still more essentially Wallacian doctrine) the sole, or even the chief, of those agents? Can isolation, or the revived Lamarckian view of the direct action of the environment, or the effects of use or disuse accumulating through generations, either singly or combined, account for all? or is it necessary to invoke the aid of any of the numerous subsidiary methods of selection which have been suggested as factors in bringing about the great result?

THE UTILITY ARGUMENT.

Any one who has closely followed these discussions, especially those bearing most directly upon what is generally regarded as the most important factor of evolution—natural selection, or "survival of the fittest"—cannot fail to have noticed the appeal constantly made to the advantage, the utility, or otherwise of special organs or modifications of organs or structures to their possessors. Those who have convinced themselves of the universal application of the doctrine of natural selection hold that every particular structure or modification of structure must be of utility to the animal or plant in which it occurs, or to some ancestor of that animal or plant, otherwise it could not have come into existence: the only reservation being for cases which are explained by the principle which Darwin called "correlation of growth." Thus the extreme natural selectionists and the old-fashioned school of teleologists are so far in agreement. On the other hand, it is held by some that numerous structures and modifications of structures are met with in nature which are manifestly useless; it is even confidently stated that there are many which are positively injurious to their possessor, and therefore could not possibly have resulted from the action of natural selection of favourable variations. Organs or modifications when in an incipient condition are especially quoted as bearing upon this difficulty. But here, it seems to me, we are continually appealing to a criterion by which to test our theories of which we know far too little, and this (though often relied upon as the strongest) is, in reality, the weakest point of the whole discussion. Of the variations of the form and structure of organic bodies we are beginning to know something. Our museums, when more complete and better organised, will teach us much on this branch of the subject. They will show us the infinite and wonderful and apparently capricious modifications of form, colour, and of texture to which every most minute portion of the organisation of the innumerable creatures which people the earth is subject. They will show us examples of marvellously complicated and delicate arrangements of organs and tissues in many of what we consider as almost the lowest and most imperfectly organised groups of beings with which we are acquainted. But as to the use of all these structures and modifications in the economy of the creatures that possess them, we know, I may almost say, nothing, and our museums will never teach us these things. If time permitted, I might give numerous examples in the most familiar of all animals, whose habits and actions are matters of daily observation, with whose life-history we are as well acquainted almost as we are of our own, of structures the purposes of which are still most doubtful. There are many such even in the composition of our own bodies. How, then, can we expect to answer such questions when they relate to animals known to us only by dead specimens, or by the most transient glimpses of the living in a state of nature, or when kept under the most unnatural conditions in confinement? And yet this is actually the state of our knowledge of the vast majority of the myriads of living beings which inhabit the earth. How can we, with our limited powers of observation and limited capacity of imagination, venture to pronounce an opinion as to the fitness or unfitness for its complex surroundings of some peculiar modification of structure found in some strange animal dredged up from the abysses of the ocean, or which passes its life in the dim seclusion of some tropical forest, and into the essential conditions of whose existence we have at present no possible means of putting ourselves in any sort of relation?

GUESSES AND ASSUMPTIONS.

How true it is that, as Sir John Lubbock says, "we find in animals complex organs of sense richly supplied with nerves, but the functions of which we are as yet powerless to explain. There may be fifty other senses as different from ours as sound is from sight; and even within the boundaries of our own senses there may be endless sounds which we cannot hear, and colours as different as red from green of which we have no conception. These and a thousand other questions remain for solution. The familiar world which surrounds us may be a totally different place to other animals. To them it may be full of music which we cannot hear, of colour which we cannot see, of sensations which we cannot conceive." The fact is that nearly all attempts to assign purposes to the varied structures of animals are the merest guesses and assumptions. The writers on natural history of the early part of the present century, who "for every why must have a wherefore," abound in these guesses, which wider knowledge shows to be untenable. Many of the arguments for or against natural selection, based upon the assumed utility or equally assumed uselessness of animal and vegetable structures, have nothing more to recommend them. In fact, to say that any part of the organisation of an animal or plant, or any habit or instinct with which it is endowed, is useless, or even injurious, seems to me an assumption which, in our present state of knowledge, we are not warranted in making. The time may come when we shall have more light, but infinite patience and infinite labour are required before we shall be in a position to speak dogmatically on these mysteries of nature—labour not only in museums, laboratories, and dissecting-rooms, but in the homes and haunts of the animals themselves, watching and noting their ways amid their natural surroundings, by which means alone we can endeavour to penetrate the secrets of their life-history. But until that time comes, though we may not be quite tempted to echo the despairing cry of the poet, "Behold, we know not anything," a frank confession of ignorance is the most straightforward, indeed the only honest position we can assume when questioned on these subjects.

SCIENTIFIC INACCURACY.

However much we may be convinced of the supreme value of scientific methods of observation and of reasoning, both as mental training of the individual and in the elucidation of truth and advancement of knowledge generally, it is impossible to be blind to the fact that we who are engaged with the investigation of those subjects which are commonly accepted as belonging to the domain of physical science are, unfortunately, not always, by virtue of being so occupied, possessed of that most precious gift, "a right judgment in all things." No one intimately acquainted with the laborious and wavering steps of scientific progress (I can answer at least for one branch of it) can look upon that progress with a perfect feeling of satisfaction. Can it be said of any of us that our observations are always accurate, the materials on which they are based always sufficient, our reasoning always sound, our conclusions always legitimate? Is there any subject, however limited, of which our knowledge can be said to have reached finality? Or if it happens to any of us as to

A man who looks at glass
On it may stay his eye,
Or if he pleases through it pass
And then the heavens espy,

are not those heavens which are beyond the immediate objects of our observation coloured by our prejudices, prepossessions, emotions, or imagination, as often as they are defined by any profound insight into the depth of nature's laws? In most of these questions an open mind and a suspended judgment appear to me the true scientific position, whichever way our inclination may lead us. For myself, I must own that when I endeavour to look beyond the glass, and frame some idea of the plan upon which all the diversity in the organic world has been brought about, I see the strongest grounds for the belief, difficult as it sometimes is in the face of the strange, incomprehensible, apparent defects in structure, and the far stranger, weird, ruthless savagery of habit, often brought to light by the study of the ways of living creatures, that natural selection, or survival of the fittest, has, among other agencies, played a most important part in the production of the present condition of the organic world, and that it is a universally acting and beneficent force continually tending towards the perfection of the individual, of the race, and of the whole living world. I can even go further and allow my dream still thus to run:—

Oh yet we trust that somehow good
Will be the final goal of ill,—

That nothing walks with aimless feet,
That not one life shall be destroyed
Or cast as rubbish to the void
When God hath made the pile complete.

VOTE OF THANKS.

The MAYOR OF NEWCASTLE (Mr. T. Richardson) moved a vote of thanks to the President for his address, and in so doing tendered to the association on behalf of the Corporation and the citizens generally a cordial welcome to Newcastle. (Cheers.) Fifty-one years had passed away since the first, and twenty-six since the second, meeting of the association at Newcastle. Many of those who had been prominently associated with the first meeting had been gathered to their fathers, but he was happy to think that many of those who took part in the second meeting were still with them, amongst them being two of their most distinguished citizens—Lord Armstrong, who was still hale and hearty—(cheers)—and Sir Lowthian Bell, who still devoted his superb abilities to scientific pursuits. (Cheers.) The years which had elapsed since they first met at Newcastle had been pregnant with the most eventful changes through which the country had ever passed. (Cheers.) Applied science had completely revolutionised the means of communication, the methods of business, and the social and commercial condition of the country. Newcastle had borne no insignificant part in the discoveries and exertions which had brought about those great changes, and because the science of Tyneside had been more applied than theoretic, it had been none the less serviceable to humanity. (Cheers.)

Lord ARMSTRONG seconded the vote of thanks. He said :—Mr. President, ladies, and gentlemen, I have great pleasure in seconding the motion of a vote of thanks to our President for the able and valuable address which he has delivered to us this evening. He has devoted the chief part of his address to the subject of the organisation and management of museums, and much that he has said upon that subject is pertinent to our own noble museum, which, under the auspices of Mr. John Hancock, has risen in this town to be an ornament and a credit to the city. No man but John Hancock could have procured the money which was needed for the erection of the building, and no one but he could have enriched its collection to the extent he has done. (Hear, hear.) John Hancock is a citizen of Newcastle, and a true one, whom Newcastle ought to be proud of, and whom future generations will be proud of. (Cheers.) He has devoted the best part of his life to the creation of that museum, and nothing now is wanting but to give full effect to his labours by a sufficient income to carry it properly on. I have done my part towards contributing to the building fund of the museum—(cheers)—and may be allowed to appeal to my fellow-citizens to enrol themselves in greater numbers as members of the society, and thereby create an income to enable it to be carried on with due efficiency. (Cheers.) Our chairman has also treated in a very philosophic spirit the great problem of evolution, and I wish that his temperate remarks upon that subject could have been more extended than they are. There has been much hasty theorising on that subject, and a vast amount of difficulty remains to be removed. We must all admit that the framework of organisation adapts itself with marvellous flexibility to the conditions of the environment. There is nothing in nature which deserves our admiration more than this capability of adaptation ; but the origin of that framework and that capability of adaptation remains as great a mystery as ever it has been before. But it is not my purpose to take up the thread of the President's address, but merely to call upon you to express your cordial thanks for his having undertaken the onerous duty of preparing and delivering the valuable address with which he has favoured us this evening. (Loud cheers.)

The MAYOR then put the vote of thanks, which was carried with acclamation.

The PRESIDENT said : I have very shortly to thank you and the Mayor and Lord Armstrong for the kind way in which they have proposed the vote of thanks to me, and the way in which you have received it. There is only one remark I should like to make, and it is this—that it is very seldom that the presidential address of this association has so very soon borne fruit as it has done to-day. The remarks Lord Armstrong has made show that it has borne fruit, and I only hope that we shall see this Museum at Newcastle not only founded, but placed on such a basis that it shall do good work. I must also thank the Mayor for the cordial welcome to the association, and thank him and his colleagues, who have worked very hard for many months past in connexion with the arrangements they have made for our reception. (Cheers.) I have to announce that before the lecture the number of tickets issued was 2,228. (Cheers.)

The proceedings then ended.

THE SECOND DAY'S PROCEEDINGS.

MEETINGS OF THE SECTIONS.

PRESIDENTIAL ADDRESSES.

THURSDAY, SEPTEMBEB 12, 1889.

President:—Professor William Henry Flower, C.B., LL.D., F.R.S., F.R.C.S., Pres. Z.S., F.L.S., F.G S., Director of the Natural History Department of the British Museum.

Vice-Presidents:—His Grace the Duke of Northumberland, K.G., D.C.L., LL.D., Lord-Lieutenant of Northumberland; the Right Hon. the Earl of Durham, Lord-Lieutenant of Durham; the Right Hon. the Earl of Ravensworth; the Right Rev. the Lord Bishop of Newcastle, D.D.; the Right Hon. Lord Armstrong, C.B., D.C.L., LL.D., F.R.S.; the Very Rev. the Warden of the University of Durham. D.D.; the Right Hon. John Morley, LL.D., M.P.; the Right Worshipful the Mayor of Newcastle; the Worshipful the Mayor of Gateshead; Sir Lowthian Bell, Bart., F.R.S., F.C.S., M. Inst. C.E.; Sir Chas. Mark Palmer, Bart., M.P.* *Nominated by the Council.

General Treasurer:—Professor A. W. Williamson, Ph. D., LL.D., F.R.S., V.P.C.S.

General Secretaries:—Captain Sir Douglas Galton, K.C.B., D.C.L., LL.D., F.R.S., F.L.S., F.G.S., F.R.G.S., A. G. Vernon Harcourt, M.A., LL.D., F.R.S., F.C.S.

Secretary:—Arthur T. Atehison, Esq., M.A.

Local Treasurer for the meeting at Newcastle-upon-Tyne:—Thomas Hodgkin, Esq., B.A., D.C.L.

Local Secretaries for the meeting at Newcastle-upon-Tyne:—Professor J. Herman Merivale, M.A.; Professor P. Phillips Bedson, D.Sc., F.C.S.

SECTION A.—MATHEMATICAL AND PHYSICAL SCIENCE.

President:—Capt. W. de W. Abney, R.E., C.B., F.R.S.L. and E., F.C.S., F.R.S.A.

Vice-Presidents:—The Right Hon. Lord Armstrong, C.B., LL.D., D.C.L., F.R.S.; Professor Arthur Cayley, M.A., D.C.L., LL.D., F.R.S., V.P.R.A.S.; Professor G. F. Fitzgerald, M.A., F.R.S.; James Glaisher, F.R.S., F.R.A.S.; Capt. A. Noble, C.B., F.R.S., F.R.A.S., F.C.S.; the Right Hon. Lord Rayleigh, M.A., D.C.L., LL.D., Sec.R.S., F.R.A.S., F.R.G.S.; Professor A. Schuster, Ph.D., F.R.S., F.R.A.S.; Sir William Thomson, M.A., LL.D., D.C.L., F.R.S.L. and E., F.R.A.S.

Secretaries:—R. E. Baynes, M.A. (Recorder); R. T. Glazebrook, M.A., F.R.S.; Alfred Lodge, M.A.; W. N. Shaw, M.A.; Professor H. Stroud, M.A., D.Sc.

Place of meeting, Durham College of Science.

ADDRESS BY CAPTAIN W. DE W. ABNEY, C.B.

The President of this section, Captain W. de W. Abney, C.B., in his inaugural remarks dealt with the subject of photography. The following are the chief points of his address:—This year is the jubilee of the practical introduction of photography by

DAGUERRE AND FOX TALBOT,

and I have thought I might venture to take up your time with a few remarks on the effect of light on matter. I have often asserted, and I again assert, that there should be no stimulus for the study of science to be compared to photography. Step by step, as it is pursued, there should be formed a desire for a knowledge of all physical science. Physics, chemistry, optics, and mathematics are all required to enable it to be studied as it should be studied; and it has the great advantage that experimental work is the very foundation of it, and results of some kind are always visible. I perhaps am taking an optimist view of the matter, seeing there are at least 25,000 living facts against my theory, and perhaps not 1 per cent of them in its favour. I mean that there are at least 25,000 persons who take photographs, and scarcely 1 per cent. who know or care anything of the "why or wherefore" of the processes, so far as theory is concerned. If we call photography an applied science, it certainly has a larger number who practise it, and probably fewer theorists, than any other.

EFFECT OF LIGHT ON SILVER SALTS.

Perhaps one of the most puzzling phenomena to be met with in photography is the fact that the range of photographic action is spread over so large a portion of the spectrum. The same difficulty of course is felt in the matter of absorption, since the one is dependent on the other. Absorption by a body we are accustomed, and indeed obliged by the law of the conservation of energy, to consider as due to the transference of the energy of the ether wave-motion to the molecules and atoms comprising the body by increasing the vibrations of one or both.

In the case where chemical action takes place we can scarcely doubt that it is the atoms which in a great measure take up the energy of the radiation falling on them, as chemical action is dependent on the liberation of one or more atoms from the molecule, whilst, when the swings of the molecules are increased in amplitude we have a rise in temperature of the body. I shall confine the few remarks I shall make on this subject to the case of chemical action. The molecule of a silver salt, such as bromide of silver, chemists are wont to look upon as composed of a limited and equal number of atoms to form the molecule. When we place a thin slab of this material before the slit of the spectroscope we find a total absorption in the violet and ultra violet of the spectrum, and a partial absorption in the blue and green, and a diminishing absorption in the yellow and red. A photographic plate containing the same salt is acted upon in exactly the same localities and in the same relative degree as where the absorption takes place. Here, then, we have an example of, it may be, the vibrations of four atoms, one of which at least is spectrum. The explanation of this is somewhat obscure. A mental picture, however, may help us. If we consider that, owing to the body acted upon being a solid, isochronous or partially so, with the waves composing a large part of the visible the oscillations of the molecules and atoms are confined to a limited space, it probably happens that between the times in which the atoms occupy, in regard to one another, the same relative positions, the component vibrations of, say, two of the atoms vary considerably in period. An example of what I mean is found in a pendulum formed of a bob and an elastic rod. If the bob be made to vibrate in the usual manner, and at the same time the elastic rod be elongated, it is manifest that we have a pendulum of ever-varying length. At each instant of time the period of vibration would differ from that at the next instant, if the oscillations were completed. It is manifest that increased amplitude would be given to the pendulum swings by a series of well-timed blows differing very largely in period; at the same time there would be positions of the pendulum in which one series of well-timed blows would produce the greatest effect. In a somewhat similar manner we should imagine that the ethereal waves should produce increased amplitude in the swing of the atoms between very wide limits of period, and, further, that there should be one or more positions in the spectrum when a maximum effect is produced. I would here remark that the shape of the curves of sensitiveness, when plotted graphically, of the different salts of silver to the spectrum have a marked resemblance to the graphically drawn curves of the three colour sensations of the normal eye, as determined by Clerk Maxwell. May not the reason for the form of the one be equally applicable for the other? I only throw this out as evidence, not conclusive indeed, that the colour-sensitiveness of the eye is more probably due to a photographic action on the sensitive retina than to a merely mechanical action. That this is the case I need scarcely say has several times been propounded before. The ease with which a silver salt is decomposed is largely, if not quite, dependent on the presence of some body which will take up some of the atoms which are thrown off from it. For instance, in chloride of silver we have a beautiful example of the necessity of such a body. In the ordinary atmosphere the chlorine is, of course, coloured by the action of light; but if it be carefully dried and purified, and placed in a good vacuum, it will remain uncoloured for years in the strongest sunlight. In this case the absence of air and moisture is sufficient to prevent it discolouring. If in the vacuum, however, a drop of mercury be introduced the coloration by light is set up. We have the chlorine liberated from the silver and combining with the mercury vapour, and a minute film of calomel formed on the sides of the vessel. Delicate experiments show that not only is this absorbent almost necessary when the action of light is so strong or so prolonged that its effect is visible, but also when the exposure or intensity is so small that the effect is invisible and only to be found by development. The necessity for this absorbent is not far to seek. If, for instance, silver chloride be exposed to light in vacuo, although the chlorine atoms may be swung off from the original molecule, yet they may only be swung off to a neighbouring molecule which has lost one of its chlorine atoms, and an interchange of atoms merely takes place. If, however, a chlorine absorbent be present which has a greater affinity for chlorine than has the silver chloride which has lost one of its atoms, then we may consider that the chlorine atoms will be on the average more absorbed by the absorbent than by the subchloride molecules. The distribution of the swung-off atoms between the absorbent and the subchloride will doubtless be directly proportional to their respective affinities for chlorine, and so for the other salts of silver. If this be so, then it will be seen that the greater the affinity of the absorbent for the halogen the more rapid will be the decomposition of the silver salt. This, then, points to the fact that if any increase in the sensitiveness of a silver salt is desired it will probably be brought about by mixing with it some stronger halogen absorbent than has yet been done.

THE PRODUCT.

The question as to what is the exact product of the decomposition of a silver salt by the action of light is one which has not as yet been fully answered. For my own part, I have my strong beliefs and my disbeliefs. I fully believe the first action of light to be a very simple one, though this simple action is masked by other actions taking place, due to the surroundings in which it takes place. The elimination of one atom from a molecule of a silver salt leaves the molecule in an unsatisfied condition, and capable of taking up some fresh atom. It is this capacity which seemingly shrouds the first action of light, since when exposure is prolonged the molecules take up atoms of oxygen from the air or from the moisture in it. Carey Lea, of Philadelphia, has within the last three years given some interesting experiments on the composition of what he calls the photochloride of silver, which is the chloride coloured by light, and Professor Hodgkinson has also taken up the matter. The conclusions the former has drawn are, to my mind, scarcely yet to be accepted. According to the latter experimentalist, the action of light on silver chloride is to form an oxidised subsalt. This can hardly be the case, except under certain conditions, since a coloured compound is obtained when the silver chloride is exposed in a liquid in which there is no oxygen present.

PHOTOGRAPHY IN NATURAL COLOURS.

This coloration by light of the chloride of silver naturally leads our thoughts to the subject of photography in natural colours. The question is often asked when photography in natural colours will be discovered. Photography in natural colours not only has been discovered, but pictures in natural colours have been produced. I am not alluding to the pictures produced by manual work, and which have from time to time been foisted on a credulous public as being produced by the action of light itself, much to the damage of photography and usually to the so-called inventors. Roughly speaking, the method of producing the spectrum in its natural colours is to chlorinise a silver plate, expose it to white light till it assumes a violet colour, heat it till it becomes rather ruddy, and expose it to a bright spectrum. The spectrum colours are then impressed in their natural tints. Experiment has shown that these colours are due to an oxidised product being formed at the red end of the spectrum and a reduced product at the violet end. Photography in natural colours, however, is only interesting from a scientific point of view, and, so far as I can see, can never have a commercial value. A process to be useful must be one by which reproductions are quickly made; in other words, it must be a developing and not a printing process, and it must be taken in the camera, for any printing process requires not only a bright light but also a prolonged exposure. Now it can be conceived that in a substance which absorbs all the visible spectrum, the molecules can be so shaken and sifted by the different rays, that eventually they sort themselves into masses which reflect the particular rays by which they are shaken; but it is almost—I might say, quite—impossible to believe that when this shifting has only been commenced, as it would be in the short exposure to which a camera picture is submitted, the substance deposited to build up the image by purely chemical means would be so obliging as to deposit in that the particular size of particle which should give to the image the colour of the nucleus on which it was depositing. I am aware that in the early days of photography we heard a good deal about curious results that had been obtained in negatives, where red brick houses were shown as red and the blue sky as bluish. The cause of these few coincidences is not hard to explain, and would be exactly the same as when the red brick houses were shown as bluish and the sky as red in a negative. The records of the production of the latter negatives are naturally not abundant, since they would not attract much attention. I may repeat, then, that photography in natural colours by a printing-out process—by which I mean by the action of light alone—is not only possible but has been done, but that the production of a negative in natural colours from which prints in natural colours might be produced appears, in the present state of our knowledge, to be impossible. Supposing it were not impracticable, it would be unsatisfactory, as the light with which the picture was impressed would be very different from that in which it would be viewed. Artists are fully aware of this difficulty in painting, and take their precautions against it.

The nearest approach to success in producing coloured pictures by light alone is the method of taking three negatives of the same subject through different coloured glasses, complementary to the three colour sensations which altogether give to the eye the sensations of white light. The method is open to objection on account of the impure colour of the glasses used. If a device could be adopted whereby only those three parts of the spectrum could be severally used which form the colour sensations, the method would be more perfect than it is at present. Even then perfection could not be attained, owing to a defect which is inherent in photography, and which cannot be eliminated. This defect is the imperfect representation of gradation of tone. For instance, if we have a strip from what we call black to white (it must be recollected that no tone can scientifically be called black, and none white), and photograph it, we shall find that in a print from the negative the darkness which is supposed to represent a grey of equal mixtures of black and white by no means does so unless the black is not as black nor the white as white as the original. The cause of this untruthfulness in photography has occupied my attention for several years, and it has been my endeavour to find out some law which will give us the density of a silver deposit on a negative corresponding with the intensity of the light acting. I am glad to say that at the beginning of this year a law disclosed itself, and I find that the transparency of a silver deposit caused by development can be put into the form of the law of error. This want of truth in photogrophy in rendering gradation, then, puts it out of the range of possibility that photography in natural colours can ever be exact, or that the three negatives system can ever get over the difficulty.

ACTION OF LIGHT ON FUGITIVE DYES.

One of the reproaches that in early days was cast at photography was its inability to render colour in its proper monochromatic luminosity. Thus whilst a dark blue was rendered as white in a print—that is, gave a dense deposit in a negative—bright yellow was rendered as black in a print or nearly so—that is, as transparent or nearly transparent glass in the negative. To the eye the yellow might be far more luminous than the blue, but the luminosity was in the photograph reversed. I need scarcely say that the reason of this want of truth in the photograph is due to the want of sensitiveness of the ordinarily used silver salts to the least refrangible end of the spectrum. Some fifteen years ago Dr. H. W. Vogel announced the fact that when silver salts were stained with certain dyes they became sensitive to the colour of the spectrum, which the dyes absorbed. This at once opened up possibilities, which, however, were not at once realised, owing perhaps to the length of exposure required when the collodion process was employed. Shortly after the gelatine process was perfected, the same dyes were applied to plates prepared by this method, which, although they contained the same silver salts as the old collodion process, yet *per se* were very much more sensitive. A new era then dawned for what has been termed isochromatic and orthochromatic photography. The dyes principally used are those belonging to the eosin group and cyanin—not the ordinary cyanine dye of commerce, but that discovered by Greville Williams. For a dye to be of use in this manner it may be taken as an axiom—first propounded by the speaker, it is believed—that it must be fugitive, or that it must be capable of forming a silver compound. The more stable a dye is the less effective it is. If we take as an example cyanine we find that it absorbs in the orange and slightly in the red. If paper or collodion stained with this colouring-matter be exposed to the action of the spectrum, it will be found that the dye bleaches in exactly the same part of the spectrum as that in which it absorbs, following, indeed, the universal law I have already alluded to. If a film containing a silver salt be dyed with the same, it will be found that, whilst the spectrum acts on it in the usual manner—viz., darkening it in the blue, violet, and ultra-violet—the colour is discharged where the dye absorbs, showing that in one part of the spectrum it is the silver salt which is sensitive, and that in the other it is the colouring-matter. If such a plate, after exposure to the spectrum, be developed it will be found that at both parts a deposit of silver takes place; and further, when the experiment is carefully conducted, if a plate with merely cyanine-coloured collodion be exposed to the spectrum and bleached in the orange, and after removal to the dark room another film containing a silver salt be applied and then a developer, a deposit of silver will take place where the bleaching has occurred. This points to the fact that the molecules of a fugitive dye, when altered by light, are unsatisfied, and are ready to take up an atom or atoms of silver, and other molecules of silver will deposit on such nuclei by an action which has various names in physical science, but which I don't care to mention. This is the theory which I have always advocated, viz., that the dye by its reduction acts as a nucleus on which a deposit of silver can take place. It met with opposition; a rival theory which makes the dye an "optical sensitiser"—an expression which is capable of a meaning which I conceive contrary to physical laws—being run against it. The objection to what I may call the nucleus theory is less vigorous than it has been, and its diminution is due perhaps to the more perfect understanding of the meaning of each other by those engaged in the controversy. To my mind, the action of light on fugitive dyes is one of the most interesting in the whole realm of photography, as eventually it must teach us something as to the structure of molecules, and add to the methods by which their coarseness may be ascertained. Be the theory what it may, however, a definite result has been attained, and it is now possible to obtain a *fair* representation of the luminosity of colours by means of dyed films. At present, the employment of coloured screens in front of the lens, or on the lens itself, is almost an essential in the method when daylight is employed, but not till some dye is discovered which shall make a film equally sensitive for the same luminosity to the whole visible spectrum will it be possible to make orthochromatic photography as perfect as it can be made. The very fact that no photograph of even a black and white gradation will render the latter correctly must of necessity render any process imperfect, and hence in the above sentence I have used the expression, "as perfect as it can be made."

PHOTOGRAPHY AND THE SPECTRUM.

The delineation of the spectrum is one of the chief scientific applications to which photography has been put. From very early days the violet and ultra-violet end of the spectrum have been favourite objects for the photographic plate. To secure the yellow and red of the spectrum was, however, till of late years, a matter of apparently insurmountable difficulty; whilst a knowledge of that part of the spectrum which lies below the red was only to be gained by its heating effect. The introduction of the gelatine process enabled the green portion of the spectrum to impress itself on the sensitive surface; whilst the addition of various dyes, as before mentioned, allowed the yellow, the orange, and a portion of the red rays to become photographic rays. Some eight years ago it was my own good fortune to make the dark infra-red rays impress themselves on a plate. This last has been too much a specialty of my own, although full explanations have been given of the methods employed. By preparing a bromide of silver salt in a peculiar manner one is able so to modify the molecular arrangement of the atoms that they answer to the swings of those waves which give rise to these radiations. By employing this salt of silver in a film of collodion or gelatine the invisible part of the spectrum can be photographed and the images of bodies which are heated to less than red heat may be caused to impress themselves upon the sensitive plate. The greatest wave-length of the spectrum to which this salt is sensitive so far is 22,000 *lambda*, or five times the length of the visible spectrum. The exposure for such a wave-length is very prolonged, but down to a wave-length of 12,000 it is comparatively short, though not so short as that required for the blue rays to impress themselves on a collodion plate. The colour of the sensitive salt is a green blue by transmitted light; it has yet to be determined whether this colour is all due to the coarseness of the particles or to the absoption by the molecules. The fact that a film can be prepared which by transmitted light is yellow, and which may be indicative of colour due to five particles, together with an absorption of the red and orange, points to the green colour being probably due to absorption by the molecules. We have thus in photography a means of recording phenomena in the spectrum from the ultra-violet to a very large wave-length in the infra-red—a power which physicists may some day turn to account. It would, for instance, be a research worth pursuing to photograph the heavens on a plate prepared with such a salt, and search for stars which are nearly dead or newly born, for in both cases the temperature at which they are may be such as to render them below red heat, and therefore invisible to the eye in the telescope. It would be a supplementary work to that being carried out by the brothers Henri, Common, Roberts, Gill, and others, who are busy securing photographic charts of the heavens in a manner which is beyond praise.

A RECENT ADVANCE.

There is one other recent advance which has been made in scientific photography to which I may be permitted to allude, namely, that from being merely a qualitative recorder of the action of light it can now be used for quantitative measurement. I am not now alluding to photographic actinometers, such as have been brought to such a state of perfection by Roscoe—but what I allude to is the measurement and interpretation of the density of deposit in a negative. By making exposures of different lengths to a standard light, or to different known intensities of light on the same plate on which a negative has to be taken, the photographic values of the light acting to produce the densities on the different parts of the developed image can be readily found. Indeed, by making only two different exposures to the same light, or two exposures to two different intensities of light, and applying the law of density of deposit in regard to them, a curve is readily made from which the intensities of light necessary to give the different densities of deposit in the image impressed on the same plate can be read off. The application of such scales of density to astronomical photographs, for example, cannot but be of the highest interest, and will render the records so made many times more valuable than they have hitherto been. I am informed that the United States astronomers have already adopted the use of such scales, which for the last three years I have advocated, and it may be expected that we shall have results from such scaled photographs which will give us information which would before have been scarcely hoped for.

AN IMPORTANT POINT.

One word as to a problem which we may say is as yet only qualitatively and not quantitatively solved. I refer to the interchangeability of length of exposure for intensity of light. Put it in this way. Suppose, with a strong light, L, a short exposure, E, be given, a chemical change, C, is obtained: will the same change C be obtained if the time is only an *n*th of the light L, but *n* times the exposure? Now this is a very important point, more particularly when the body acted upon is fairly stable, as, for instance, some of the water-colour pigments, which are known to fade in sunshine, but might not be supposed to do so in the light of an ordinary room, even with prolonged exposure. Many experiments have been made at South Kensington as regards this, more especially with the salts of silver, and it is found that for any ordinary light, intensity and exposure are interchangeable, but that when the intensity of light is very feeble, say the 1-1000000th of ordinary daylight, the exposure has to be rather more prolonged than it should be, supposing the exact interchangeability always held good; but it has never been found that a light was so feeble that no action could take place. Of course it must be borne in mind that the stability of the substance acted upon may have some effect; but the same results were obtained with matter which is vastly more stable than the ordinary silver salts. It may be said in truth that almost all matter which is not elemental is, in time and to some degree, acted upon by light.

TWO MARVELS OF THE CENTURY.

The discovery of the action of light on silver salts is one of the marvels of this century, and it is difficult to overrate the bearing it has had on the progress of science, more especially physical science. The discovery of telegraphy took place in the present reign, and two years later photography was practically introduced; and no two discoveries have had a more marked influence on mankind. Telegraphy, however, has had an advantage over photography in the scientific progress that it has made, in that electrical currents are subject to exact measurement, and that empiricism has no place with it. Photography, on the other hand, has laboured under the disadvantage that, though it is subject to measurement, the factors of exactitude have been hitherto absent. In photography we have to deal with molecules, the equilibrium of whose components is more or less indifferent according to the process used; again, the light employed is such a varying factor that it is difficult to compare results. Perhaps more than any other disadvantage it labours under is that due to quackery of the worst description at the hands of some of its followers, who not only are self-asserting, but often ignorant of the very first principles of scientific investigation. Photography deserves to have followers of the highest scientific calibre; and if only some few more real physicists and chemists could be induced to unbend their minds and study the theory of an applied science which they often use for record or for pleasure, we might hope for some greater advance that has hitherto been possible. Photography has been called the handmaid of art; I venture to think it is even more so the handmaid of science, and each step taken in perfecting it will render it more worthy of such a title.

Sir **William Thompson** moved a vote of thanks to the president for his address. He had rarely listened with so much pleasure to a scientific address. The amount of information which had been brought before them in that address was really very remarkable, and he thought in all respects they would be most grateful to Captain Abney for his most charming and interesting statement. In reference to Section A, they ought to express the great pleasure they felt in looking round that beautiful room and thinking how happy the meetings of Section A would be there in comparison with the very moderate amount of happiness, so far as the room was concerned, that they had experienced in several other places, which would be in the recollection of many present. (Laughter.) He thought that room with the appliances for experimental illustration in connexion with it must be looked upon with satisfaction by members of the association. It was a great benefit to them to have such a place for their meetings, and he was sure the association would feel very great sympathy with those citizens and public bodies of Newcastle who devoted themselves so much to the establishment of that college of science. (Applause.) The University of Durham gave very important material assistance to carry on the work, but he understood that more was wanted. (Laughter.) If the citizens of Newcastle knew how tremendously appreciated such work was by the rest of the world they would be encouraged not merely to stop with the building, but to take an interest in the institution always. (Cheers.)

Lord **Rayleigh** seconded the motion. After commenting on several statements in the address, he said the section was most fortunate in having the subject put before them by Capt. Abney, to whom everybody looked for information on the subject to which he had addressed himself. (Hear, hear.)

The motion having been adopted,

The **President** returned thanks, and replied briefly to the comments of Lord Rayleigh.

TIDAL OBSERVATION.

Mr. **Barnes**, the recorder of the section, read the report of the committee appointed for the purpose of promoting tidal observations in Canada. The report said that in May last the committee had an interview with the Hon. C. Tupper, the present Minister of Marine, on the purpose for which they were appointed. The Minister expressed himself as entirely favourable to the institution of the proposed tidal observations, but said that the financial position as regarded the expenditure on hydrographic surveys was such that no steps could be taken as yet in the matter. The committee believed that since the interview some of the expenditure in hydrographic surveys had ceased, and as there was reason to believe that other Cabinet Ministers were in favour of the proposed measure, the committee deemed the prospects of carrying it into execution very satisfactory. There was no doubt about the anxiety of shipmasters to have the tidal investigations got on foot immediately, and the Royal Society of Canada deemed the matter of such great practical importance that at their last meeting they appointed a special committee to give energetic support to the action of the British Association committee.—The report was adopted.

No reports were made by the committees on the Practical work of Tidal Observation and on the Harmonic Analysis of Tidal Observation.

THE SPECTRA OF TUBES.

A paper on the re-examination of the spectra of 23 gas vacuum end-on tubes after six to ten years existence and use had been prepared by Professor C. Piazzi Smith, late Astronomer Royal for Scotland. In the absence of the professor, an abstract of his paper was read by Mr. R. E. Baynes, the recorder of the section. Professor Smith, in his paper, said that inquiry began in an attempt to ascertain by refined mensurations whether there was any sensible difference of spectra plate for hydrogen lines when they appeared adventitiously and scantily in tubes of other and very different gases, or in tubes of nothing but fine and abundant hydrogen by original intention. After obtaining a negation in every case the inquirer became more taken up with the changes that had occurred in certain of the tubes subsequent to 1880, when he published upon them in the Transactions of the Royal Society, Edinburgh. Thus a chlorine tube which was still showing its chlorine lines in 1880, after two years' use, whilst carbon bands and hydrogen lines had begun to appear, yet now, in 1889, had nothing but hydrogen lines, and those in great brilliance, to show. Similar instances were mentioned, and the author mentioned with great satisfaction, that M. Casella, a London maker, had supplied him with one tube of CO., two of N, and two of O, which had, after six years of existence and work, shown their respective spectra without a trace of hydrogen.—There was no discussion on the paper.

A paper on the "Heliocentric Longitudes of Cometic Perihelia," was read by Mr. HenryMoorshead, M.D., LL.D.

COMETIC NEBULÆ.

Professor A. W. **Rucker**, F.R.S., read a paper on "Cometic Nebulæ." He said Professor Lockyer had suggested that comet-like nebulæ might be caused by the passage of a very dense swarm through a street of meteorites, the relative velocity of the two being considerable. The author had, therefore, attempted to calculate the increase in the number of collisions which took place in the rear of an attractive mass which passed through a swarm of meteorites so sparsely scattered through space that the main effects of the attraction were produced in distance which was small compared with the length of the mean free path. Assuming that the particles had equal velocities equally distributed in all directions, and which were small compared with the relative velocity of the approach, the collisions would be most numerous within a cone the apex of which was the attractive body of the nucleus and which containing the lines which were parallel to the relative velocity of the individual meteorites and the nucleus when at an infinite distance apart. The collisions would increase enormously when the nebulæ came nearer the sun, and would take place about every second, at points in round numbers 100 miles apart.

Sir W. **Thompson** suggested that the tremendous augmentation of the number of collisions might possibly be the cause of the increased luminosity, and that after all the energising effect of the sun upon the comet causing the comet to seem to have more luminous energy, was not due to the heat of the sun, but an indirect effect of the sun's gravitation.

Professor **Rucker** having answered one or two questions, a vote of thanks was accorded him for his paper.

THE TONES OF BELLS.

Lord **Rayleigh** read a paper on this subject, in which he said observations had been made upon a considerable number of bells of the usual church pattern. The pitch of the various tones, usually five for each bell, were fixed by comparison with a harmonium and with the aid of resonators. The various tones of any bell corresponded to various modes of vibration. The quality of sounds was very difficult to estimate, and even the imperfect octaves, of which several examples were secured, gave much less of a dissonant effect than might have been expected. The sounds in all cases became less clear as the edge was departed from. The speaker depicted on the blackboard a table of the Terling peal of bells.—A short discussion followed, and the speaker was thanked for his address.

SEISMOLOGICAL WORK IN JAPAN.

Professor **Milne**, of the Imperial University of Japan, read a paper on "Seismological Work in Japan." The Seismological Society of Japan had for several years made attempts to record earthquakes by using the old type of earthquake instruments. The records obtained from instruments of this order were, however, gradually recognised as being too indefinite—the instruments failing to measure the shakings they indicated. All investigators recognised that to measure the movement of the earth it was necessary, while the movement was going on, to obtain a steady point or platform relatively to which the motion might be measured. By the patient labours of investigators in Japan, which had extended over many years, this had been accomplished, and they now had pendulums and other forms of instruments which for small displacements were in neutral equilibrium, so that, when the frames carrying these instruments were shaken backwards and forwards, or up and down, certain portions of them remained at rest. From these steady points pointers projected which wrote the movements or magnified representations of their movements upon suitably-prepared surfaces. With the assistance of these instruments many thousands of diagrams, each representing the backwards and forwards motions of the ground during an earthquake, had been obtained, and they now knew the true nature of earthquake—movement. They had learned that in many earthquakes which were quite perceptible, and sometimes even alarming, the amplitude of motion might not exceed a millimeter; while, if it reached 25 millimetres, or an inch, they might expect cities to be ruined. The results of a study of these diagrams were numerous and interesting. They now knew that the direction of movement in any given earthquake was continually vaving. At one moment a point on the surface of the earth might be moving north and south, and the next moment it would be moving east and west; while at other times it might be following a path too intricate to be easily described. Some earthquakes commenced with preliminary tremors which had been recorded with a frequency of 8 or 10 waves per second. At the end of a disturbance the wave period was always very much greater than it was at the commencement or middle of a disturbance. The speaker then went on to mention the earth currents and oscillations experienced, and at the close was warmly applauded.

VIBRATION OF RAILWAY TRAINS.

Professor **Milne** contributed a second and most interesting address on the "Vibrations of Railway Trains." He exhibited a new instrument for recording these vibrations, and explained the nature of its work. This instrument recorded both the vertical and longitudinal motion of the trains, and was of use to traffic managers and to inspectors of mines. It would localise faults, and indicate when and for what time stoppage had occurred to trains.

Sir W. **Thompson** said the investigations made by Mr. Milne were of practical value to science, and should be supported by the Association. The practical value of the instrument spoke for itself, and it was one which no railway manager would care to be without. The instrument would be also most useful in determining the amount of oscillation of railway carriages.

The **President** regretted that, the time for adjournment having arrived, the papers of Mr. Milne could not be more fully discussed.

SECTION B.—CHEMICAL SCIENCE.

President:—Sir Lowthian Bell, Bart., D.C.L., F.R.S., F.C.S., &c.

Vice-Presidents:—Sir F. A. Abel, D.C.L., F.R.S.; Professor P. P. Bedson, D.Sc.; J. H. Gladstone, Ph.D., F.R.S.; Professor F. R. Japp, M.A., LL.D., F.R.S.; Professor G. D. Liveing, M.A., F.R.S.; Professor H. M'Leod, F.R.S.; Professor J. E. Reynolds, M.A., F.R.S.; W. J. Russell, Ph.D., F.R.S.; Dr. E. Schunck, F.R.S.; Professor W. A. Tilden, D Sc., F.R.S.

Secretaries:—H. Forster Morley, M.A., D.Sc., F.C.S. Recorder); D. H. Nagel, M.A.: Dr. W. W. J. Nicol, M.A., F.R.S.E.; H. L. Pattinson, jun.

Place of meeting, Durham College of Science.

ADDRESS BY SIR LOWTHIAN BELL.

The President of this section, Sir Lowthian Bell, Bart., pointed out that chemical science was advancing so rapidly that it was impossible to adequately review, as had been the practice. He intended, therefore, to devote himself to comparing the rate of progress of the metallurgy of iron, with and without the aid which chemistry was capable of affording. While it would be unfair to those who were engaged in the manufacture of iron during the first half of the present century to deny the value of the services rendered to their art, without giving much thought to the laws of nature upon which their processes depended, it was not to be denied that since the ironmasters had allied themselves with the chemist they had made more progress in thirty years than their predecessors did in three centuries. He described, in an interesting manner, what he termed the archæology of the iron industry, and continued :—The discovery which led to the discontinuance of the low blastfurnace as a means of procuring iron in its malleable form was that of

PUDDLING

made by Cort in 1784. In point of fact Cort's process was merely doing in a reverberatory furnace that which was previously effected by means of compressed air. In an economic point of view, however, the difference is great, and its consequences were of immense importance, for to the puddling furnace we were first indebted for an ample supply of cheap iron by which, in a variety of well-known ways, the interests of the human race have been so largely promoted. As an indication of the indifference of those formerly engaged in industrial pursuits to the scientific aspect of their calling, may be mentioned the fact that puddling had been largely followed for upwards of half a century before it occurred to any one to examine the chemistry of the process. Down to the beginning of the seventeenth century the only fuel used in the blast furnace, and, indeed, in the manufacture of iron generally, was charcoal. In 1620 Dudley made several attempts to substitute mineral coal for vegetable fuel in his smelting works, which, by the exhaustion of timber, had become very expensive. He failed in this, and in consequence the British iron trade gradually fell until it was not equal to the production of one modern blast furnace. This happened in 1740, when Darby, by treating pit coal in the same fashion as the charcoal burners had done with wood, *i.e.*, by charring it, restored vitality to an expiring industry. It is true the restoration must have been of a languid character, for in half a centuty afterwards it is said the weekly produce of a furnace did not exceed fifteen or sixteen tons. Various changes were introduced into the manufacture of iron in the first quarter of the present century, but these were rather of a mechanical than of a chemical nature. They chiefly owed their origin to the lessons taught by the chemist Black to James Watt, who profited by them in the application of steam as a motive power. This brings us to the year 1828, a year which will always be distinguished in the annals of the iron trade, by the discovery of Neilson of

THE VALUE OF HEATED AIR

in smelting the ores of this metal. I never heard it pretended that this inventor had any pretensions to be considered a man of science. Had it been otherwise, the knowledge of the virtues of the hot blast might have been indefinitely postponed, and this opinion is founded on the fact that for many a long year no satisfactory explanation was given why heat obtained by burning coal in the hot air apparatus was capable of saving three or four times its weight in the fuel consumed in the furnace itself.

A WASTEFUL PROCESS.

The President considered this point in some detail, and continued :—Something like forty years ago the escaping gases from the blast furnaces, rich as they were in carbonic oxide, were permitted to burn wastefully on the surface of the minerals charged at the throat. This meant a loss of about 54 per cent. of the heating power of the coke. For reasons already given it was of course impossible to utilise much of this heat in the actual smelting of the ore because of the necessity of preserving a large excess of carbonic oxide in the gases. This, however, constituted no reason why, apart from the furnace work itself, this vast quantity of gaseous fuel should not have been utilised, as it no doubt would earlier have been, had the ironmakers known, as they now do, its full value. To-day all the blast and other engines are driven and the air is heated at our blast furnaces by fuel formerly wasted, and this without any labour for stoking being required. In Great Britain alone the annual saving is fully equal to four million tons of coal.

AMMONIA IN IRON SMELTING.

In connexion with the other volatile products which accompany the iron smelters' work I will only mention ammonia. Some qualities of coal admit of being used in the raw state. In this case, as in distilling coal for illuminating purposes, ammonia is generated and may be collected. Instead, however, of the ammoniacal vapour being all contained in the hydrocarbons as in gas-making, it is diluted in addition with all the fixed carbon as oxides and all the nitrogen of the atmospheric air used in its combustion. Nevertheless, Messrs. Bairds, of the Gartsherrie works, and others, are manufacturing large quantities of ammonia sulphate from the ammonia so obtained. A similar object is achieved by attaching the necessary condensers to the apparatus for coking coal. The process of distillation is then carried on in hermetically closed ovens heated by the combustion of the gases evolved. These, before reaching the fire-place where they are burnt, are deprived of their ammoniacal vapours by passing through condensers provided for the purpose. Previous, however, to this being done, the waste heat from the coking process had been applied for generating steam, so that at certain collieries in the county of Durham all the mechanical power is obtained without any coal being specially burnt for this purpose.

STEEL.

Before speaking of the next and last great improvements in connexion with my subject, I should like to say a few words, and a few words only, respecting steel, a well-known and most valuable compound of iron and carbon. Let me first observe that it seems improbable that this substance was not earlier known to the ancients, as was at one time supposed. The facility with which the metal combines with carbon renders it very unlikely that acieration would not occasionally take place when iron itself was the object of the manufacturer. Certain it is that Agricola, who wrote in 1556, describes in Latin a mode, apparently as well known as that of making iron itself, of making *Acie*. The engraving in his "De re metallica" shows bars of malleable iron placed upright in a charcoal fire resembling that of a Catalan hearth. These, after an exposure of several hours to the incandescent charcoal and hot carbonic oxide, were found changed to steel and employed as such. After the invention of the blastfurnace, pig iron was placed in a similar hearth, and while in a melted state a blast of air was directed upon the molten metal, until just as much carbon remained with the iron as constituted steel. This mode of procedure continued to be practised long within my own recollection, and may, for what I know, still be followed in some districts. The subject of steel-making occupied the attention of Hassenfratz, of Réaumur, and others, but practically the only process followed until 1865 was the well-known one of cementation. Since the days of Fourcroy it was ascertained that in addition to the iron carbon was an essential ingredient in cast metal, but invariably accompanied by more or less silicon, and whenever the minerals contained sulphur or phosphorus these metalloids were also present. The nature of the actions employed for ridding the product of the blast furnace of these substances so as to render it malleable had also been carefully examined and explained by the light of scientific investigation. The manufacturer had, it is true, learnt by experience and observation how to produce an article of excellence without much knowledge of the science of his art. Among other things he ascertained that to obtain a ton of wrought iron he required the heat of an equal weight of coal in the puddling furnace; but he did not know, nor did even men of science, I think, ever dream, that the oxidation of the metalloids in the pig-iron, and that of a small portion of the metal itself, would afford heat enough to enable the workman to dispense with the use of all coal in the process of conversion. When, therefore, the iron trade was informed in a paper read before the British Association in 1856, entitled "A mode of making iron without the use of fuel," its author,

HENRY BESSEMER,

was set down by the iron trade as a deluded enthusiast. At that period I doubt whether ten pounds of wrought iron had ever been seen in a state of fusion at one time. Bessemer in his description, however, spoke of melting tons of it with no more heat than that afforded by the rapid oxidation of about 5 or 6 per cent. of the weight of the pig iron used. Not only therefore was the subject one of economic, but also of high scientific interest. Nevertheless, a mere statement of the title of the paper was all the notice bestowed by our predecessors in their "transactions" on a discovery which has revolutionised the art of making iron. It is quite true that for some time it appeared as if the scientific aspect of the question were to constitute its only recommendation, for the malleable iron made in a Bessemer converter proved unmanageable when hot, and destitute of strength when cold. Finally it was ascertained that phosphorus was the source of the evil, and, further, that while carbon and silicon could be almost entirely removed from the molten metal, this third metalloid remained unaffected by the treatment. The first success was obtained in Sweden, where by using pig iron containing a mere trace of the objectionable substance a product was obtained which was satisfactory. For many years the beneficial effect produced by manganese on steel had been well known, and it occurred to R. F. Mushet, son of David Mushet, one of, if not the earliest scientific metallurgist in the United Kingdom, to try its influence in the converter on iron made from the hematite iron of the West of England, which contained from ·05 to ·1 per cent. of phosphorus. This addition, apparently by its removing occluded or combined oxygen in the molten iron, afforded the necessary relief, and the operation being one of extreme simplicity enables steel or wrought iron to be produced at a greatly reduced cost. To such an extent has this been carried, that ore is brought by sea over a distance of 1,000 miles to Middlesbrough, and from it steel rails are made more cheaply than a greatly inferior article of iron can be produced from the abundant and economically wrought bed of ironstone found within a couple of miles of that town. As an example of the facility of conversion may be adduced the fact that the molten metal is brought direct from the blast furnace, turned into steel or ingot iron, as the case may be, and the heat evolved by the operation is sufficient to enable the product in many cases, without further use of fuel, to be taken direct to the mill and rolled into a finished bar.

THE SIEMENS' FURNACE.

We have just seen that ·1 per cent., or thereabouts, of phosphorus renders steel or ingot iron valueless; in like manner very insignificant variations in the quantities of carbon or silicon materially affect their quality. Now the blow, as it is termed, in a Bessemer converter may be accomplished in from twelve to fifteen minutes. It is clear, therefore, the opportunity of ascertaining the precise quality of the steel is one of very short duration. It is, I think, not disputed that a product can be obtained by this process possessed of very high, if indeed not of the highest, excellence, but it is also pretended that the quality is not sufficiently uniform for certain purposes. The ordinary reverberatory furnace is incapable of affording the necessary temperature for melting steel or wrought iron, but by employing the fuel in a gaseous state, and by heating the air and gas before they are brought together, as is done in the valuable furnace suggested by the Messrs. Siemens, the heat is so intensified that wrought iron in it is rapidly fused. Steel is now largely made in such furnaces, either by mixing wrought and cast iron, as proposed by M. Pierre Martin, or by means of cast iron alone, when the carbon is removed by the addition of iron ore and some limestone, in which case, by the agency of the ore, the metalloids are oxidised and removed from the bath of iron. Some hours being required for this, sufficient opportunity is afforded for ascertaining the progress of the operation.

THE THOMAS AND GILCHRIST PROCESS.

The cause of the iron in the Siemens furnace as well as in the Bessemer converter retaining its associated phosphorus in time began to attract the attention of chemists. The rapid destruction of the ordinary Bessemer converter led Mr. G. I. Snelus to consider the practicability of using a lime lining, and on experimenting with this on a working scale he confirmed the opinions previously enunciated by Grüner by observing that the presence of lime had removed a considerable quantity of the phosphorus. These discoveries constitute the foundation of the very important basic process of Messrs. Thomas and Gilchrist, which consists in adding lime to the molten steel in a converter constructed on the principle described by Mr. Snelus. Considerable difficulty had, however, been experienced by this metallurgist in the attachment of the lime lining to the walls of the converter. This important question was solved by Mr. Edw. Riley by exposing dolomite to a very high temperature in order to prevent further shrinking, and then grinding and mixing the powder with coal tar. This formed a species of cement which is applied to the sides and bottom of the converter in the form of bricks or as cement. Doubtless, simple as the idea is, it has greatly contributed to the success of the basic process.

BASIC SLAG AS MANURE.

The acidification and subsequent transference to the slag of the phosphorus by the basic treatment has led to its application to agriculture. For this purpose the slag is ground to a fine powder and sprinkled over the land without any further preparation. By this operation an indispensable element of animal life is derived from the remains of living creatures which, ages ago, found a grave in the ferruginous mud destined to become the great Cleveland bed of ironstone.

TECHNICAL EDUCATION.

Before closing this portion of my official duty I cannot refrain from tendering to chemists an assurance of the great advantage the manufacturers of iron feel they have derived from the lessons taught them by chemical science. I am the more anxious to do this because we, among others, have been reminded that we are losing the supremacy among industrial nations we once enjoyed for want of that knowledge of chemistry which is more assiduously cultivated abroad than it is in our own country. I am not prepared to deny that the opportunities for acquiring a scientific education are less generally spread here than is the case in France, Germany, or Belgium, but for this the nation, and not the iron trade in particular, is responsible. It must also be admitted that as manufacturers we no longer stand so far above other lands as we formerly did. In this result any differences of education are in no way concerned, for if I were to classify the nationalities of the various inventions enumerated in the course of my remarks the fears of those who are alarmed at the appearance of a Belgian girder or a German steam engine on our shores would, I think, be allayed. Perhaps I might be allowed to offer a very few words on the technical side of this important question of education. Much I shall not be able to say, because I have not yet been able to learn the precise position the subject occupies in the minds of its most earnest advocates. If it means, as is sometimes alleged, a system by which, along with scientific instruction, manual dexterity in the use of tools or a practical knowledge of various manufacturing processes has to be acquired, I confess I am not sanguine as to the results. My objection to the whole system is the impossibility of anything approaching a general application being practicable. I have not a word to say against the rudiments of science being taught wherever this is possible. The knowledge so obtained may often give the future workman a more intelligent interest in his employment than he at present possesses, but I think they who expect much good to attend such a thin veneer of chemistry or physics do not take sufficient account of the extent of the knowledge already possessed by more highly educated men who are now directing the great workshops of the world. It is by extending and enlarging this that substantial aid has to be afforded to industry and science, and not by teaching a mere smattering in our primary or any other schools. In the case of young people who from necessity must leave the schoolroom at an early age, my own leaning is towards the present system, with the addition of drawing and some natural science.

As a national question the attention of the Government, Imperial or municipal, ought to be directed to the importance of establishing in all great manufacturing centres institutions resembling that of the Physical College of this city. These should consist of appropriate and even handsome buildings, properly furnished with all the instruments and appliances required for teaching the sciences in their practical bearings on industrial pursuits. In Newcastle, as well as in other places, this has been done on a fairly ample scale, and the advantages the College of Science in this city are capable of affording are offered on such terms that no one can plead expense being a barrier to mental improvement. Bearing in mind the importance of the subject, and remembering, as my colleagues and myself do, the difficulties we have had to encounter and those we have still before us, I am strongly of opinion that the erection and maintenance of colleges of science should not be left to the accidental liberality of the few, but should be taken in hand by the nation at large.

Sir F. A. **Abel** proposed, and Dr. E. **Schunck** seconded, a vote of thanks to Sir Lowthian Bell for presiding over the section and for the valuable address he had given. Sir F. A. Abel added that Sir Lowthian Bell was not only known as one who had obtained eminence such as to make all who were interested in chemistry and in the iron industry read carefully the clear and lucid sketch given. They would know that much of the progress in the iron industries was largely contributed to by the President. (Applause.) He remembered his first visit to Newcastle in connexion with the British Association twenty-six years ago. One of the most interesting points to the chemists was that of the visits to places themselves interesting, under the guidance of the Mayor of Newcastle then. And he ventured to think that in one work Mr. Bell then was connected with, and which had led to great results since—he referred to aluminium—the labours of their president had been of vast benefit. In reference to the remarks of the president as to technical education, he would add that no men were more alive to its advantages than those who had, as manufacturing chemists, to struggle against difficulties in every step they had taken.

The vote of thanks was then carried by acclamation, and briefly acknowledged by Sir I. L. Bell.

SILICON IN STEEL.

Mr. R. A. **Hadfield** then read the third report of the committee (Professors Tilden and Roberts-Austen and Mr. Turner) appointed for the purpose of investigating the influence of silicon on the properties of steel. In this Mr. Hadfield said that silicon had been blamed in a hasty manner. The common belief that alloys of carbon, silicon, and iron are brittle or even dangerous was quite correct, but the cause was not due to silicon alone, but to the combination of silicon with carbon and iron. It was also pointed out by Mr. Howe that silica is often mistaken for silicon, and it might be responsible for the metalloid's bad name. The results of mechanical tests on steel, tensile, bending, and compression tests, were given to show that apparently silicon up to 1½ or 1¾ per cent. added to iron, although increasing the limit of elasticity and raising the tensile strength, did not impair ductility, but, after this, the further increase of tensile strength noticed was obtained only with a serious loss of ductility.

STANDARD FOR IRON ANALYSIS.

The report of the committee appointed at the Bath meeting on the best method of establishing an international standard for the analysis of iron and steel was submitted by Mr. Turner. It stated that correspondence had taken place with allied institutions, and that it was hoped that by the next meeting of the association the work would be in a forward condition.

EIKONOGEN.

A paper on "Eikonogen, a New Photographic Developer," by Professor Liveing, followed.

LEAD OXIDE AND GLASS.

A note on the "Volatilisation of Lead Oxide and its Action upon Glass at Low Temperatures" was read by Mr. J. W. Hogg. It described a few experiments to show that oxide of lead will corrode or attack glass, and also volatilise in small quantities at a temperature of scarcely visible redness. If oxide of lead be used as a pigment to write or mark upon a polished plate of glass, and thus is then heated to the above-named temperature for about one hour, upon cooling and brushing off the surplus oxide there will be found a distinct corrosion or etching upon the surface, due to the oxide having entered into combination with the constituents of the glass; this action will take place even below visible redness, in which case the corroded surface is quite smooth; if the operation be conducted at a decided red heat the appearance is like that of a dry hydrofluoric acid etching. Very pretty results may be obtained by converting this surface corrosion into sulphide of lead; this is easily done by soaking the plate in a solution of ammonium sulphide; brilliant mirror-like films of sulphide of lead may be obtained under certain conditions. It has also been found that if a plate of glass be heated to a scarcely visible redness its polish is extremely sensitive to the slightest trace of lead vapour. To render this evident it is only necessary to place upon a glass plate or platinum foil some writing, using oxide of lead as a pigment; if a polished plate of glass be placed over this as closely as possible, and prevented from actual contact by suitable means, upon now heating up to the previously mentioned temperature for not less than an hour, a distinct reverse of the design will appear upon the surface of the upper glass; the quantity of lead oxide which will produce this effect is not shown by the most delicate balance.

POTASSIUM FERROCYANIDE.

After a paper on "The Molecular Weight of Metals—an application of Raoult's Method to Alloys" by Messrs. C. T. Heycock, M.A., and F. H. Neville, M.A., a paper on "The Manufacture of Prussiate of Potash" was read by Dr. J. B. **Readman**. The first portion of this paper refers to the present condition of this manufacture, describing the present process as very wasteful and imperfect, and shows that very little attention has of late years been devoted to improving the process, which has remained stationary for nearly half a century. A general sketch of the process now employed in manufacturing prussiate is next given. Then follows a brief notice of the history of prussiate since its discovery last century, and of the processes that have been proposed or patented to improve the manufacture, and lastly, full details of a series of experiments made by the author to produce prussiate by the action of ammonia gas upon red-hot wood charcoal which had been previously saturated with carbonate of potash.

SECTION C.—GEOLOGY.

President:—Professor James Geikie, LL.D., F.R.S.L. and E., F.G.S.

Vice-Presidents:—H. B. Brady, F.R.S.; Professor A. H. Green, M.A., F.R.S.; Chevalier Max von Hantken; John Marley; Pierre de Tchihatchef.

Secretaries:—Professor G. A. Lebour, M.A., F.G.S.; J. E. Marr, M.A., F.G.S.; W. W. Watts, M.A., F.G.S. (Recorder); H. B. Woodward, F.G.S.

Place of meeting, the New Assembly Rooms.

ADDRESS BY PROFESSOR JAMES GEIKLE, L.L.D.

Professor James Geikie, LL.D., in his inaugural address to this section, gave an outline of some of the results obtained during the last few years by continental workers in the domain of glacial geology. Below we give the chief points in his remarks:—

The results obtained by geologists, who have been studying the peripheral areas of the drift-covered regions of our continent, are such as to satisfy us that the drifts of those regions are not iceberg-droppings, as we used to suppose, but true morainic matter and fluvio-glacial detritus. Geologists have not jumped to this conclusion—they have only accepted it after laborious investigation of the evidence. Since Dr. Otto Torell, in 1875, first stated his belief that the "diluvium" of North Germany was of glacial origin a great literature on the subject has sprung up, a perusal of which will show that with our German friends glacial geology has passed through much the same succession of phases as with us. At first icebergs are appealed to as explaining everything—next we meet with sundry inegnious attempts at a compromise between floating-ice and a continuous ice-sheet. As observations multiply, however, the element of floating-ice is gradually eliminated, and all the phenomena are explained by means of land-ice and "schmelz-wasser" alone. It is a remarkable fact that the iceberg hypothesis has always been most strenuously upheld by geologists whose labours have been largely confined to the peripheral areas of drift-covered countries. In the upland and mountainous tracts, on the other hand, that hypothesis has never been able to survive a moderate amount of accurate observation. That the notion of a general ice-sheet having covered a large part of Europe, which a few years ago was looked upon as a wild dream, has been amply justified by the labours of those who are so assiduously investigating the peripheral area of the "great northern drift." And perhaps I may be allowed to express my own belief that the drifts of Middle and Southern England, which exhibit the same complexity as the "lower diluvium" of the Continent, will eventually be generally acknowledged to have had a similar origin. I now pass on to review some of the general results obtained by continental geologists as to the extent of area occupied by inland ice during the last great extension of glacier-ice in Europe. It is well known that this latest ice-sheet did not overflow nearly so wide a region as that underneath which the lowest boulder-clay was accumulated. Gerard de Geer has given a summary of the general results obtained by himself and his fellow-workers in Sweden and Norway; and these have been supplemented by the labours of Berendt, Geinitz, Hunchecorne, Keilhack, Klockmann, Schröder, Wahnschaffe, and others in Germany, and by Sederholm in Finland. From them we learn that the end-moraines of the ice circle round the southern coasts of Norway, from whence they sweep south-east by east across the province of Gottland in Sweden, passing through the lower ends of Lakes Wener and Wetter, while similar moraines mark out for us the terminal front of the inland ice in Finland—at least two parallel frontal moraines passing inland from Hango head on the Gulf of Finland through the southern part of that province to the north of Lake Ladoga. Further north-east than this they have not been traced; but, from some observations by Helmersen, Sederholm thinks it probable that the terminal ice-front extended north-east by the north of Lake Onega to the eastern shores of the White Sea. Between Sweden and Finland lies the basin of the Baltic, which at the period in question was filled with ice, forming a great Baltic glacier, which overflowed the Aland Islands, Gottland, and Oland, and which, fanning out as it passed towards the south-west, invaded, on the south side, the Baltic provinces of Germany, while, on the north, it crossed the southern part of Scania in Sweden and the Danish islands to enter upon Jutland.

The general conclusions arrived at by those who are at present investigating the glacial accumulations of Northern Europe may be summarised as follows:—

1. Before the invasion of Northern Germany by the inland ice the low grounds bordering on the Baltic were overflowed by a sea which contained a boreal and arctic fauna. These marine conditions are indicated by the presence under the lower boulder-clay of more or less well-bedded fossiliferous deposits. On the same horizon occur also beds of sand, containing fresh-water shells, and now and again mammalian remains, some of which imply cold and others temperate climatic conditions. Obviously all these deposits may pertain to one and the same period, or more properly to different stages of the same period—some dating back to a time when the climate was still temperate, while others clearly indicate the prevalence of cold conditions, and are therefore probably somewhat younger.

2. The next geological horizon in ascending order is that which is marked by the "Lower Diluvium"—the glacial and fluvio-glacial detritus of the great ice-sheet which flowed south to the foot of the Harz Mountains. The boulder-clay on this horizon now and again contains marine, fresh-water, and terrestrial organic remains, derived undoubtedely from the so-called preglacial beds already referred to. These latter, it would appear, were ploughed up and largely incorported with the old ground-moraine.

3. The interglacial beds which next succeed contain remains of a well-marked temperate fauna and flora, which point to something more than a mere partial or local retreat of the inland ice. The geographical distribution of the beds and the presence in these of such forms as *Elephas antiquus*, *Cervus elephas*, *C. megaceros*, and a flora comparable to that now existing in Northern Germany, justify geologists in concluding that the interglacial epoch was one of long duration, and characterised in Germany by climatic conditions apparently not less temperate than those that now obtain. One of the phases of that interglacial epoch, as we have seen, was the overflowing of the Baltic provinces by the waters of the North Sea.

4. To this well-marked interglacial epoch succeeded another epoch of arctic conditions, when the Scandinavian inland ice once more invaded Germany, ploughing through the interglacial deposits, and working these up in its groundmoraine. So far as I can learn, the prevalent belief among geologists in North Germany is that there was only one interglacial epoch; but, as already stated, doubt has been expressed whether all the facts can be thus accounted for. There must always be great difficulty in the correlation of widely-separated interglacial deposits, and the time does not seem to me to have yet come when we can definitely assert that all these interglacial beds belong to one and the same geological horizon.

I have dwelt upon the recent work of geologists in the peripheral areas of the drift-covered regions of Northern Europe, because I think the results obtained are of great interest to glacialists in this country. And for the same reason I wish next to call attention to what has been done of late years in elucidating the glacial geology of the Alpine lands of Central Europe—and more particularly of the low grounds that stretch out from the foot of the mountains. Any observations that tend to throw light upon the history of the complex drifts of our own peripheral areas cannot but be of service. The only question concerning the ground-moraines that has recently given rise to much discussion is the origin of the materials themselves. It is obvious that there are only three possible modes in which those materials could have been introduced to the ground-moraine; either they consist of superficial morainic debris which has found its way down to the bottom of the old glaciers by crevasses; or they may be made up of the rock-rubbish, shingle, gravel, &c., which doubtless strewed the valleys before these were occupied by ice; or, lastly, they may have been derived in chief measure from the underlying rocks themselves by the action of the ice that overflowed them. The investigations of Penck, Blaas, Böhm, and Brückner appear to me to have demonstrated that the ground-moraines are composed mostly of materials which have been detached from the underlying rocks by the erosive action of the glaciers themselves. Their observations show that the regions studied by them in great detail were almost completely buried under ice, so that the accumulation of superficial moraines was for the most part impossible; and they advance a number of facts which prove positively that the ground-moraines were formed and accumulated under ice. These geologists do not deny that some of the material may occasionally have come from above, nor do they doubt that pre-existing masses of rock-rubbish and alluvial accumulations may have been incorporated with the groundmoraines; but the enormous extent of the latter, and the direction of transport and distribution of the erratics which they contain cannot be thus accounted for, while all the facts are readily explained by the action of the ice itself, which used its subglacial débris as tools with which to carry on the work of erosion.

Professor Heim and others have frequently asserted that glaciers have little or no eroding power, since at the lower ends of existing glaciers we find no evidence of such erosion being in operation. But Dr. Blaas has been led by his observations on the glacial formation of the Inn valley to recant his former views, and to become a formidable advocate of the very theory which he formerly opposed. To his work and the memoirs by Penck, Brückner, and Böhm already cited, and especially to the admirable chapter on glacier-erosion by the last-named author, I would refer those who may be anxious to know the last word on this much-debated question.

The evidence of interglacial conditions within the Alpine lands continues to increase. These are represented by alluvial deposits of silt, sand, gravel, conglomarate, breccia, and lignites. Penck, Böhm, and Brückner find evidence of two interglacial epochs, and maintain that there have been three distinct and separate epochs of glaciation in the Alps. No mere temporary retreat and re-advance of the glaciers, according to them, will account for the phenomena presented by the interglacial deposits and associated morainic accumulations. During interglacial times the glaciers disappeared from the lower valleys of the Alps—the climate was temperate, and probably the snow-fields and glaciers approximated in extent to those of the present day. All the evidence conspires to show that an interglacial epoch was of prolonged duration. Dr. Brückner has observed that the moraines of the last glacial epoch rest here and there upon löss, and he confirms Penck's observations in South Bavaria that this remarkable formation never overlies the morainic accumulations of the latest glacial epoch. According to Penck and Brückner, therefore, the löss is of interglacial age. There can be little doubt, however, that löss does not belong to any one particular horizon. Wahnschaffe and others have shown that throughout wide areas in North Germany it is the equivalent in age of the "Upper Diluvium," while Schumacher points out that in the Rhine valley it occurs on two separate and distinct horizons. Professor Andreæ has likewise shown that there is an upper and lower löss in Alsace — each characterised by its own special fauna. There is still considerable difference of opinion as to the mode of formation of this remarkable accumulation. By many it is considered to be an aqueous deposit; others, following Richthofen, are of opinion that it is a wind-blown accumulation; while some incline to the belief that it is partly the one and partly the other. Nor do the upholders of these various hypotheses agree amongst themselves as to the precise manner in which water or wind has worked to produce the observed results. Thus, amongst the supporters of the aqueous origin of the löss, we find this attributed to the action of heavy rains washing over and rearranging the material of the boulder-clays. Many, again, have held it probable that löss is simply the finest loam distributed over the low grounds by the flood-waters that escaped from the northern inland ice and the *mers de glace* of the Alpine lands of Central Europe. Another suggestion is that much of the material of the löss may have been derived from the denudation of the boulder-clays by flood-water, during the closing stages of the last cold period. It is pointed out that in some regions at least the löss is underlaid by a layer of erratics, which are believed to be the residue of the denuded boulder-clay. We are reminded by Klockmann and Wahnschaffe that the inland ice must have acted as a great dam, and that wide areas in Germany, &c., would be flooded, partly by water derived from the melting inland ice, and partly by waters flowing north from the hilly tracts of Middle Germany. In the great basins thus formed there would be a commingling of fine silt-material derived from north and south, which would necessarily come to form a deposit having much the same character throughout.

From what I have myself seen of the löss in various parts of Germany, and from all that I have gathered from reading and in conversation with those who have worked over löss-covered regions, I incline to the opinion that löss is for the most part of aqueous origin. In many cases this can be demonstrated, as by the occurrence of bedding and the intercalation of layers of stones, sand, gravel, &c., in the deposit; again, by the not infrequent appearance of fresh-water shells; but, perhaps, chiefly by the remarkable uniformity of character which the löss itself displays. It seems to me reasonable also to believe that the flood-waters of glacial times must needs have been highly charged with finely-divided sediment, and that such sediment would be spread over wide regions in the low grounds—in the slack-waters of the great rivers and in the innumerable temporary lakes which occupied, or partly occupied, many of the valleys and depressions of the land. There are different kinds of löss or löss-like deposits, however, and all need not have been formed in the same way. Probably some may have been derived, as Wahnschaffe has suggested, from the denudation of boulder-clay. Possibly, also, some löss may owe its origin to the action of rain upon the stony clays, producing what we in this country would call "rain-wash." There are other accumulations, however, which no aqueous theory will satisfactorily explain. Under this category comes much of the so-called *Berglöss*, with its abundant land-shells, and its generally unstratified character. It seems likely that such löss is simply the result of subaerial action, and owes its origin to rain, frost, and wind acting upon the superficial formations, and rearranging their finer-grained constituents. And it is quite possible that the upper portion of much of the löss of the lower grounds may have been reworked in the same way. But I confess I cannot yet find in the facts adduced by German geologists any evidence of a dry-as-dust epoch having obtained in Europe during any stage of the Pleistocene period. It is obvious, however, that after the flood-waters had disappeared from the low grounds of the Continent, subaerial action would come into play over the wide regions covered by glacial and fluvio-glacial deposits. Thus, in the course of time, these deposits would become modified, just as similar accumulations in these islands have been top-dressed, as it were, and to some extent even rearranged. I am strengthened in these views by the conclusions arrived at by M. Falsan, the eminent French glacialist. Covering the plateaux of the Dombs, and widely spread throughout the valleys of the Rhone, the Ain, the Isère, &c., in France, there is a deposit of löss, he says, which has been derived from the washing of the ancient moraines. At the foot of the Alps, where black schists are largely developed, the löss is dark grey; but west of the secondary chain the same deposit is yellowish, and composed almost entirely of silicious materials, with only a very little carbonate of lime. This *limon* or löss, however, is very generally modified towards the top by the chemical action of rain, the yellow löss acquiring a red colour. Sometimes it is crowded with calcareous concretions; at other times it has been deprived of its calcareous element and converted into a kind of pulverulent silica or quartz. This, the true löss, is distinguished from another *lehm*, which Falsan recognises as the product of atmospheric action—formed, in fact, in place from the disintegration and decomposition of the subjacent rocks. Even this lehm has been modified by running water—dispersed or accumulated locally, as the case may be.

All that we know of the löss and its fossils compels us to include this accumulation as a product of the Pleistocene period. It is not of postglacial age—even much of what one may call the "remodified löss" being of Late Glacial or Pleistocene age. I cannot attempt to give here a summary of what has been learned within recent years as to the fauna of the löss. The researches of Nehring and Liebe have familiarised us with the fact that at some particular stage in the Pleistocene period a fauna like that of the alpine steppe-lands of Western Asia was indigenous to Middle Europe, and the recent investigations of Woldrich have increased our knowledge of this fauna. At what horizon, then, does this steppe-fauna make its appearance? At Thiede, Dr. Nehring discovered in so-called löss three successive horizons, each characterised by a special fauna. The lowest of these faunas was decidedly arctic in type; above that came a steppe-fauna, which last was succeeded by a fauna comprising such forms as mammoth, woolly rhinoceros, *Bos*, *Cervus*, horse, hyæna, and lion. Now, if we compare this last fauna with the forms which have been obtained from true postglacial deposits — those deposits, namely, which overlie the younger boulder clays and flood-accumulations of the latest glacial epoch, we find little in common. The lion, the mammoth, and the rhinoceros are conspicuous by their absence from the postglacial beds of Europe. In place of them, we meet with a more or less arctic fauna, and a high-alpine and arctic flora, which, as we all know, eventually gave place to the flora and fauna with which Neolithic man was contemperaneous. As this is the case throughout North-Western and Central Europe, we feel justified in assigning the Thiede beds to the Pleistocene period, and to that interglacial stage which preceded and gradually merged into the last glacial epoch.

If the student of the Pleistocene faunas has certain advantages in the fact that he has to deal with forms many of which are still living, he labours at the same time under disadvantages which are unknown to his colleagues who are engaged in the study of the life of far older periods. The Pleistocene period was distinguished above all things by its great oscillations of climate—the successive changes being repeated, and producing correlative migrations of floras and faunas. We know that arctic and temperate faunas and floras flourished during interglacial times, and a like succession of life-forms followed the final disappearance of glacial conditions. A study of the organic remains met with in any particular deposit will not necessarily, therefore, enable us to assign these to their proper horizon. The geographical position of the deposit, and its relation to Pleistocene accumulations elsewhere must clearly be taken into account. Already, however, much has been done in this direction, and it is probable that ere long we shall be able to arrive at a fair knowledge of the various modifications which the Pleistocene floras and faunas experienced during that protracted period of climatic changes of which I have been speaking. We shall even possibly learn how often the arctic, steppe, prairie, and forest faunas as they have been defined by Woldrich, replaced each other. Even now some approximation to this better knowledge has been made. Dr. Pohlig, for example, has compared the remains of the Pleistocene faunas obtained at many different places in Europe, and has presented us with a classification which, although confessedly incomplete, yet serves to show the direction in which we must look for further advances in this department of inquiry.

During the last twenty years the evidence of interglacial conditions both in Europe and America has so increased that geologists generally no longer doubt that the Pleistocene period was characterised by great changes of climate. The occurrence at many different localities on the Continent of beds of lignite and fresh-water alluvia, containing remains of Pleistocene mammalia, intercalated between separate and distinct boulder-clays, has left us no alternative. The interglacial beds of the Alpine lands of Central Europe are paralleled by similar deposits in Britain, Scandinavia, Germany, and France. But opinions differ as to the number of glacial and interglacial epochs—many holding that we have evidence of only two cold stages and one general interglacial stage. This, as I have said, is the view entertained by most geologists who are at work on the glacial accumulations of Scandinavia and North Germany. On the other hand, Dr. Penck and others, from a study of the drifts of the German Alpine lands, believe that they have met with evidence of three distinct epochs of glaciation, and two epochs of interglacial conditions. In France, while some observers are of opinion that there have been only two epochs of general glaciation, others, as for example, M. Tardy, find what they consider to be evidence of several such epochs. Others again, as M. Falsan, do not believe in the existence of any interglacial stages, although they readily admit that there were great advances and retreats of the ice during the Glacial period. M. Falsan, in short, believes in oscillations, but he is of opinion that these were not so extensive as others maintained. It is, therefore, simply a question of degree, and whether we speak of oscillations or of epochs, we must needs admit the fact that throughout all the glaciated tracts of Europe, fossiliferous deposits occur intercalated among glacial accumulations. The successive advance and retreat of the ice, therefore, was not a local phenomenon, but characterised all the glaciated areas. And the evidence shows that the oscillations referred to were on a gigantic scale.

The relation borne to the glacial accumulations by the old river alluvia which contain relices of palæolithic man early attracted attention. From the fact that these alluvia in some places overlie glacial deposits, the general opinion (still held by some) was that palæolithic man must needs be of postglacial age. But since we have learned that all boulder-clay does not belong to one and the same geological horizon—that, in short, there have been at least two, and probably more, epochs of glaciation—it is obvious that the mere occurrence of glacial deposits underneath palæolithic gravel does not prove these latter to be postglacial. All that we are entitled in such a case to say is simply that the implement-bearing beds are younger than the glacial accumulations upon which they rest. Their horizon must be determined by first ascertaining the relative position in the glacial series of the underlying deposits. Now, it is a remarkable fact that the boulder-clays which underlie such old alluvia belong, without exception, to the earlier stages of the Glacial period. This has been proved again and again, not only for this country but for Europe generally. I am sorry to reflect that some twenty years have now elapsed since I was led to suspect that the palæolithic gravels and cave-deposits were not of post-glacial but of glacial and interglacial age. In 1871-72 I published a series of papers in the *Geological Magazine* in which I set forth the views I had come to form upon this interesting question. In these papers it was maintained that the alluvia and cave deposits could not be of postglacial age, but must be assigned to preglacial and interglacial times, and in chief measure to the latter. Evidence was led to show that the latest great development of glacier-ice in Europe took place after the southern pachyderms and palæolithic man had vacated England—that during this last stage of the Glacial period man lived contemporaneously with a northern and alpine fauna in such regions as Southern France—and lastly, that palæolithic man and the southern mammalia never revisited North-Western Europe after extreme glacial conditions had disappeared. These conclusions were arrived at after a somewhat detailed examination of all the evidence then available—the remarkable distribution of the palæolithic and ossiferous alluvia having, as I have said, particularly impressed me. I coloured a map to show at once the areas covered by the glacial and fluvio-glacial deposits of the last glacial epoch, and the regions in which the implement-bearing and ossiferous alluvia had been met with, when it became apparent that the latter never occurred at the surface within the regions occupied by the former. If ossiferous alluvia did here and there appear within the recently glaciated areas it was always either in caves, or as infra- or interglacial deposits. Since the date of these researches our knowledge of the geographical distribution of Pleistocene deposits has greatly increased, and implements and other relics of palæolithic man have been recorded from many new localities throughout Europe. But none of this fresh evidence contradicts the conclusions I had previously arrived at; on the contrary, it has greatly strengthened my general argument.

Thus as years advance the picture of Pleistocene times becomes more and more clearly developed. The conditions under which our old palæolithic predecessors lived—the climatic and geographical changes of which they were the witnesses—are gradually being revealed with a precision that only a few years ago might well have seemed impossible. This of itself is extremely interesting, but I feel sure that I speak the conviction of many workers in this field of labour when I say that the clearing up of the history of Pleistocene times is not the only end which they have in view. One can hardly doubt that when the conditions of that period and the causes which gave rise to these have been more fully and definitely ascertained we shall have advanced some way towards the better understanding of the climatic condition of still earlier periods.

It would almost seem as if all one had to do to ascertain the climatic condition of any particular period was to prepare a map, depicting with some approach to accuracy the former relative position of land and sea. With such a map could our meteorologists infer what the climatic conditions must have been? Yes, provided we could assure them that in other respects the physical conditions did not differ from the present. Now there is no period in the past history of our globe the geological conditions of which are better known than the Pleistocene. And yet when we have indicated these upon a map we find that they do not give the results which we might have expected. The climatic conditions which they seem to imply are not such as we know did actually obtain. It is obvious, therefore, that some additional and perhaps exceptial factor was at work to produce the recognised results. What was this disturbing element, and have we any evidence of its interference with the operation of the normal agents of climatic change in earlier periods of the world's history? We all know that various answers have been given to such questions. Whether amongst these the correct solution of the enigma is to be found time will show. Meanwhile, as all hypothesis and theory must starve without facts to feed on, it behoves us as working geologists to do our best to add to the supply. The success with which other problems have been attacked by geologists forbids us to doubt that ere long we shall have done much to dispel some of the mystery which still envelopes the question of geological climates.

Dr. **JOHN EVANS**, in moving a vote of thanks to the president for his address, said he thought it was to be regretted that so many of our English geologists were content to limit themselves to the phenomena that were exhibited in the limited area of the British Isles. It was only by a correlation of the beds that were to be seen extending over a large area of Europe that they could attain a proper knowledge of what had taken place in this country.

Professor **H. HULL**, director of the Geological Survey of Ireland, seconded the motion, and rejoiced to think that amongst the views Professor Geikie had abandoned was that of a Polar ice sheet. He confessed for himself that he never heard that view advocated without having a thrill of horror or a sort of shiver at the idea of a Polar ice sheet. That view had been abandoned, and he was glad of it. (Hear, hear.)

The vote of thanks was carried with acclamation, and Prof. Geikie returned thanks.

EARTHQUAKE AND VOLCANIC PHENOMENA IN JAPAN.

Professor **JOHN MILNE** presented a report on "Earthquake and volcanic phenomena in Japan," the committee consisting of Mr. R. Etheridge, Professor Thomas Gray, and Professor John Milne. Professor Milne said the most severe earthquake which was recorded occurred on Feb. 18, 1889, at 6h. 9min. 32sec. a.m. Diagrams of that earthquake were obtained at the Imperial Meteorological Observatory, and by Professor S. Sekiya and himself at the University. Professor Sekiya said that after the commencement of the shock there were gentle tremors lasting twelve seconds. These were followed by violent motions, having a range of a little less than twelve millimetres, in a direction about N ·60 E; at the Meteorological Observatory the range of motion was 20 millimetres, with a period of 2·2secs. The period of vibration recorded by Professor Sekiya was 1·9 second. From these quantities it appeared that the least maximum velocity was 16·5 millimetres, whilst the maximum acceleration per second was 54·6 millimetres. On January 15, 1887, an earthquake occurred which had a maximum acceleration of 66 millimetres per second in soft ground, and 36 millimetres per second on hard ground. On February 22, 1880, an earthquake occurred, and in Tokio it seemed that the acceleration was 90 or 100 millimetres per second. Of records taken by means of post cards he sent out it appeared that about 41 per cent. of the shocks felt in Tokio were of local origin. The 36 shocks which were felt in Tokio, and which shook a large tract of the country, might be divided as follows:—1. Shocks which were felt all over Tokio—6. 2. Shocks which practically were only felt upon the hilly hard ground upon the west side of Tokio—30. From the above they might conclude that 36 per cent. of the earthquakes which shook an enormous area of ground outside Tokio only shook the hilly part of Tokio itself. The shocks which disturbed the whole of Tokio each had on the average at the same time shaken a much larger area than those which were only noticed on the high ground, and further, those which were felt by the residents on the low ground had on the average a much shorter period than those which were only felt on the high ground. This latter observation might explain why so many shocks were not recorded on the low ground. Another explanation was that in many instances a vibratory motion passing beneath Tokio might only reach the surface where the superincumbent soft materials were thin—that was, upon the hills—the relatively thick deposit of soft material on the low ground absorbing the motion like a buffer. Notwithstanding the above observations, he was yet of opinion that the high and hard ground was better than the low soft ground so far as safety was concerned, for earthquake motion was always greater on the low soft ground than it was on the high ground. At the suggestion of Mr. John Macdonald, superintendent of the locomotive department at Shinbashi, in Tokio, he was led to make experiments on the vibration of locomotives. Through the kindness of Mr. Frank Trevethick, C.E., the general superintendent of the Shinbashi works, he was able to test a considerable number of contrivances, and he thought he might fairly state that he had obtained an instrument which practically gave an absolute measure of the horizontal and vertical vibrational movements of locomotives. These vibrations were recorded as three components—one vertical, one longitudinal, and one transverse. Each of these components was recorded by a brass pointer writing on metallic paper covering a revolving drum. The diagrams were, therefore, continuous, and gave a record of all the vibrations of an engine while on a given journey. Amongst other things they showed, 1st, variations in the speed of a train; 2nd, they showed all the places where a train might have stopped, and the duration of the stoppage; 3rd, the relative extent of motions in different directions; 4th, from the diagrams much might be learnt about the nature of a track. The curves on the lines were clearly marked, soft ground was indicated, and irregularities due to faultiness in the track were recorded. Although the instrument was not directly connected with seismological work, it was a useful outcome of such work, and it had given valuable suggestions as to the construction of seismographs for large earthquakes, in which there were undoubtedly quick and sudden changes in level. The paper concluded with forms of building construction best adapted to withstand earthquakes.

Mr. **G. MITCHIE SMITH** presented a report on the Bandaisan Eruption in Japan, on July 15th, 1888. He said the eruption commenced with a violent shaking of the ground, and while the ground was moving there was a terrific explosion, followed by about twenty other explosions. The result of the explosion was to blow out one side of Kobandai, leaving a horseshoe-like cliff crater, 1½ square miles in area, and, according to the calculation of Prof. Sekiya, to remove 1,587 million cubic yards of material, weighing 2,982 millions of tons, from the upper part of the mountain. This material, consisting of earth and rocks, some of which were 30ft. in diameter, suddenly rolled down the mountain with a velocity of about 48 miles per hour. A remarkable feature of the explosion was that it was accompanied by a terrible hurricane, which levelled houses and tore up trees. Another remarkable phenomenon was a number of conical holes from two or three to 20 or 30 feet in diameter, and eight or ten feet in depth. These holes might be said to exist in thousands, and many of them were several miles from the crater. That they were not formed by steam was testified by the fact that, so far as he was aware, no observer observed any steam escaping from them, and the mud around them was always cold. The view he had advanced to explain their origin was, that they were formed by the earthquake shock backing up the watery strata which burst to the surface at points of least resistance.

TERRESTRIAL MAGNETISM.

Professor Perry read a paper by Dr. Edward Naumann, of Munich, on Terrestrial Magnetism as modified by the earth's crust. The author showed by many references to maps that the magnetic curves of the earth show a distinct relation to mountain ranges, faults, eruptions, and tectonic disturbances wherever a detailed magnetic survey has been made, and he urged that this work should at once be taken up all over the world.

Dr. WOODWARD said there was great value and interest attaching to Professor Milne's work. Professor Milne, who had been assisted by his colleague, Mr. Gray, of Glasgow, had invented a number of very interesting and valuable machines for registering earthquake phenomena, and those machines had proved to be of the greatest value in quite another direction. They were first invented to register earthquake phenomena, but they had shown that they were also of the greatest value for railways and other purposes. So that out of observations on the natural phenomena attending earthquakes had come what would probably prove of great value in a commercial and economic sense.

Dr. GEIKIE was sure he interpreted the feelings of the geologists of this country when he expressed his own gratitude to Professor Milne for the extraordinary energy and attention with which he had studied the question of earthquakes.

FOSSIL FOOTPRINTS IN NORTHUMBERLAND.

Mr. T. P. BARKAS, F.G.S., Newcastle, read a paper entitled "Notes on numerous newly discovered Fossil Footprints on the Lower Carboniferous Sandstone of Northumberland, near Otterburn." The object of the brief notes was to record the discovery of numerous and varied ichnological impressions on the carboniferous sandstones of Northumberland, and to make generally known a rich and almost unknown field for ichnological research in the near neighbourhood of the locality in which the annual meeting of the British Association is being held for the present year. The writer in the introduction to his paper traced the history of ichnology from the footprints discovered on the new red sandstone rocks of Scotland in 1828, the labyrinthodont marks in 1834, the numerous ichnological impressions on Permian rocks in the United States of America, by Dr. Deane and Dr. Hitchcock, between 1836 and 1844 (and published in the "American Journal of Science"), and further ichnological discoveries by Dr. Dawson, Sir W. E. Logan, Mr. Brown, and Mr. G. W. Smith, down to 1884. The footprints described by the writer were discovered by the late Mr. R. B. Sanderson, in 1871, since which time Mr. Barkas has frequently visited and searched the locality, which is on the Northumberland Moors, near Otterburn, at a height of 900 feet. Very numerous and varied impressions have been found, consisting of the footmarks of four, three, and two-toed creatures perfectly new to science; slabs containing illustrations of each were placed on the lecture table for examination, and the paper was illustrated by graphic sketches on the blackboard. The district was said to be very rich in ichnological remains, and ardent geologists were urged to enter upon an early investigation of the district.

Dr. WOODWARD said Mr. Barkas had been collecting all his life, and very valuable results had accrued from his careful observations. There were quite a number of small reptiles in the coal measures, and some of these reptiles had no doubt left behind them the tracks they now saw. It would be interesting to correlate those marks with those collected by Mr. Atthey and Mr. Hancock and other explorers in the coal measures of this region, and endeavour to see whether it was possible to relate those tracks and the animals that made them.

The PRESIDENT said he had for many years paid considerable attention to the carboniferous strata of Scotland, but in none of the Scotch beds had he found marks so clearly defined as those brought by Mr. Barkas. Unquestionably in many of our fine flaggy beds they found a number of very curious markings, which could not be explained as inorganic markings. Some of them certainly were impressions of some kind or other.

PHYSIOGRAPHY OF THE LOWER TRIAS.

Mr. T. MELLARD READE, C.E., F.G.S., F.R.I.B.A., read a paper on this subject. The following is an abstract:— After an introduction describing the various views held by geologists as to the origin of the Triassic rocks of Britain, the author states that circumstances have lately provided an opportunity for a detailed examination by him of considerable areas of the Trias in the North-West of England. As a result of this he has been drawn towards a consideration of the attractive speculations on the origin of these rocks which have emanated from various geologists. Describing the lacustrine theory suggested by the late Mr. Godwin-Austin, and supported by Sir Andrew Ramsay, the author agrees with Professor Bonney that it does not account satisfactorily for the extensive areas of marine current-bedded sandstones constituting the base of the Trias, and known as the Bunter. He considers that the prevalence of pebble-beds in these rocks, as well as the absence of thick beds of marl, is inconsistent with such an origin. Further, referring to the sub-aërial river delta theory brought forward in substitution by Professor Bonney, he contends that, while explaining the deposition of current-bedded sandstones, there is no evidence of the existence at the time of such peculiar physiographical conditions as would be required for the building up of a sub-aërial delta of sand from 1,200 to 2,000 feet thick. Such a delta would require to be fed from a high plateau or from Alpine granitic ranges, of the former existence of which we have no evidence. The author considers, from his studies of mountain ranges, that such a permanent feature of the earth's surface, had it existed, would not have so totally disappeared, while lesser ranges like the Pennine Chain have survived. It is also pointed out that the rivers of Asia and Africa feeding deltaic sands, which the Bunter is compared to, frequently disappear in them by absorption and desiccation leaving saline deposits, while in the Bunter of the North-West of England there is little or no evidence of such conditions having obtained. In suggesting another possible origin for the Bunter sandstones, it is pointed out that the rocks which are preserved appear to lie in the deeper part of the basins in which they were deposited, and that there has been here and there a remarkable preservation of the ancient orthographic features, modified, it is true, by folding and faulting. In support of this it is shown that a subsidence of 400 feet would cover most of the Trias by the sea, which would approximately follow in its margin the present Triassic boundaries. Where the Triassic deposits are bounded by the mountains of Wales and by the Pennine Chain or other high land, the overlapping of the present boundaries by the sandstones was limited; but there is every reason to suppose that there was a wide extension of them occupying the site of the Irish Sea. It is contended that these features most probably represent subsided valleys or arms of the sea previously occupied by partly denuded permians, and the author thinks that tidal action is capable of selecting the materials for and constructing, under conditions pointed out, thick, massive beds of sandstone, current-bedded, with intercalated conglomerate beds or with well-rounded quartzite pebbles distributed sparsely throughout the rock, or in nests, as found in all these forms in the Bunter sandstones. Two papers by the author on tidal action as a geological agent, in the "Philosophical Magazine," and the "Proceedings of the Liverpool Geological Society," were referred to in explanation of the physical questions involved. It is suggested that a granitic area, such as would be exposed now by an elevation of, say, 1,000 feet, occupying the site of the English Channel, together with the old red sandstone beds of the anticlinal axis connecting the Mendips with the Belgian coal field, reinforced by the sand derived from the immense destruction of carboniferous sandstone which we know has taken place in the Pennine Chain and in other areas, together with the denudation of the Old Red or Hereford, may have supplied the materials for the

Triassic rocks, which were distributed and built up by tidal action in straits, seas, and bays. The details of the process of elimination of the quartz granules, their distribution over great areas, and frequent rounding by wind action are fully discussed. It is also suggested that the quartz boulders and pebbles have most probably travelled from the south, as they are less in number and smaller in Lancashire than in the conglomerate of Bridgnorth. To the objection that no marine fossils are present in the Bunter sandstone, the author, while allowing a considerable amount of force to the circumstance, points out that it is only negative evidence, proverbially unsafe, and sets against it the absence of saline deposits, which we would expect on the subaërial delta theory. Finally, it is shown that the distribution of the lower Triassic sandstones is inconsistent with a fluvatile origin.

The PRESIDENT said, while all could not agree with the paper, the writer of it deserved their thanks.

SECTION D.—BIOLOGY.

President:—Professor J. S. Burdon Sanderson, M.A., M.D., LL.D., F.R.S.L. and E.

Vice-Presidents: — Professor G. S. Brady, M.D., F.R.S., F.L.S.; Rev. Canon Norman, M.A., D.C.L., F.L.S.; O. Salvin, M.A., F.R.S., F.L.S.; Rev. Canon Tristram, D.D., LL.D., F.R.S., F.L.S.; Professor S. H. Vines, M.A., D.Sc., F.R.S., F.L.S.

Secretaries:—C. Bailey, F.L.S.; F. E. Beddard, M.A., F.Z.S.; S. F. Harmer, B S.; Professor T. Oliver, M.D.; Professor H. Marshall Ward, M.A., F.R.S., F.L.S. (Recorder).

Place of meeting, the New Assembly Rooms.

ADDRESS BY PROFESSOR J. S. BURDON SANDERSON.

In the unavoidable absence of the president (Professor J. S. Burdon Sanderson) through illness, the chair was occupied by the Rev. Canon Tristram, one of the vice-presidents, who expressed his regret that illness prevented the president of the section from meeting the members, and proceeded to read the address which had been prepared for the occasion by Dr. Burdon Sanderson.

Professor Burdon Sanderson was prevented from illness from revising his address and giving all the references he would have desired. In his opening, he compared the science of morphology and physiology, and went on to say:—No one who is awake to the tendencies of thought and work in physiology can fail to have observed that the best minds are directed with more concentration than ever before to those questions which relate to the elementary endowments of living matter, and that if they are still held in the background it is rather because of the extreme difficulty of approaching them than from any want of appreciation of their importance. It is to some of these questions that I am anxious to draw the attention of the section to-day.

The work of investigating the special functions of organs, which during the last two decades has yielded such splendid results, is still proceeding, and every year new ground is being broken and new and fruitful lines of experimental inquiry are being opened up: but the further the physiologist advances in this work of analysis and differentiation, the more frequently does he find his attention arrested by deeper questions relating to the essential endowments of living matter, of which even the most highly differentiated functions of the animal or plant organism are the outcome. In our science the order of progress has been hitherto and will continue to be the reverse of the order of nature. Nature begins with the elementary and ends with the complex (first the amœba, then the man). Our mode of investigation has to begin at the end.

It is not difficult to see whither this method must eventually lead us. For inasmuch as function is more complicated than structure, the result of proceeding, as physiology normally does, from structure to function, must inevitably be to bring us face to face with functional differences which have no structural difference to explain them. Thus, for example, if the physiologist undertakes to explain the function of a highly differentiated organ like the eye, he finds that up to a certain point, provided that he has the requisite knowledge of dioptrics, the method of correlation guides him straight to his point. He can mentally or actually construct an eye which will perform the functions of the real eye, in so far as the formation of a real image of the field of vision on the retina is concerned, and will be able thereby to understand how the retinal picture is transferred to the organ of consciousness. Having arrived at this point he begins to correlate the known structure of the retina with what is required of it, and finds that the number of objects which he can discriminate in the field of vision is as numerous as, but not more numerous than, the parts of the retina, *i.e.*, the cones which are concerned in discriminating them. So far he has no difficulty; but the method of correlation fails him from the moment that he considers that each object point in the field of vision is coloured, and that he is able to discriminate not merely the number and relations of all the object points to each other, but the colour of each separately. He then sees at once that each cone must possess a plurality of endowments for which its structure affords no explanation. In other words, in the minute structure of the human retina we have a mechanism which would completely explain the picture of which I am conscious, were the objects composing it possessed of one objective quality only, being colourless, but it leaves us without explanation of the differentiation of colour.

By multiplying examples of the same kind, we should in each case come to the same issue, namely, plurality of function with unity of structure, the unity being represented by a simple structural element—be it retinal cone or cell—possessed of numerous endowments. Whenever this point is arrived at in any investigation structure must for the moment cease to be our guide, and, in general, two courses or alternatives are open to us. One is to fall back on that worn-out *Deus ex machina*, protoplasm, as if it afforded a sufficient explanation of everything which cannot be explained otherwise, and accordingly to defer the consideration of the functions which have no demonstrable connexion with structure as for the present beyond the scope of investigation; the other is, retaining our hold of the fundamental principle of correlation, to take the problem in reverse, *i.e.*, to use analysis of function as a guide to the ultra-microscopical analysis of structure.

I need scarcely say that of these two courses the first is wrong, the second right, for in following it we still hold to the fundamental principle that living material acts by virtue of its structure, provided that we allow the term structure to be used in a sense which carries it beyond the limits of anatomical investigation, *i.e.*, beyond the knowledge which can be attained either by the scalpel or the microscope. We thus (as I said) proceed from function to structure, instead of the other way.

At present the fundamental questions in physiology, the problems which most urgently demand solution, are those which relate to the endowments of apparently structureless living matter, and the problem of the future will be the analysis of these endowments. With this view what we have to do is, first, to select those cases in which the vital process offers itself in its simplest form, and is consequently best understood; and, secondly, to inquire how far in these particular instances we may, taking as our guide the principle I have so often mentioned as fundamental, viz., the correlation of structure with function, of mechanism with action, proceed in drawing inferences as to the mechanism by which these vital processes are actually carried out.

The most distinctive peculiarity of living matter as compared with non-living is that it is ever changing while ever the same, *i.e.* that life is a state of ceaseless change. For our present purpose I must ask you, first, to distinguish between two kinds of change which are equally characteristic of living organisms, namely, those of growth and decay on the one hand, and those of nutrition on the other. Growth the biologist calls evolution. Growth means the unfolding, *i.e.*, development of the latent potentialities of form and structure which exist in the germ, and which it has derived by inheritance. A growing organism is not the same to-day as it was yesterday, and consequently not quite the same now as it was a minute ago, and never again will be. This kind of change I am going to ask you to exclude from consideration altogether at this moment, for in truth it does not belong to my subject, but rather to that of morphology, and to limit your attention to the other kind which includes all other vital phenomena. I designated it just now as nutrition, but this word expresses my meaning very inadequately. The term which has been used for half a century to designate the sum or complex of the non-developmental activities of an organism is "exchange of material," for which Professor Foster has given the very acceptable substitute metabolism. Metabolism is only another word for "change," but in using it we understand it to mean that, although an organism in respect of its development may never be what it has been, the phases of alternate activity and repose which mark the flow of its life-stream are recurrent. Life is a cyclosis in which the organism returns after every cycle to the same point of departure, ever changing yet ever the same.

It is this antithesis which constitutes the essential distinction between the two great branches of biology, the two opposite aspects in which the world of life presents itself to the inquiring mind of man. Seen from the morphological side, the whole plant and animal kingdom constitutes the unfolding of a structural plan which was once latent in a form of living material of great apparent simplicity. From the physiological side this apparently simple material is seen to be capable of the discharge of functions of great complexity, and therefore must possess corresponding complexity of mechanism. It is the nature of this invisible mechanism that physiology thirsts to know. Although little progress has as yet been made, and little may as yet be possible, in satisfying this desire, yet, as I shall endeavour to show you, the existing knowledge of the subject has so far taken consistent form in the minds of the leaders of physiological thought, that it is now possible to distinguish the direction in which the soberest speculation is tending.

The non-developmental vital functions of protoplasm are the absorption of oxygen, the discharge of carbon dioxide and water and ammonia, the doing of mechanical work, the production of heat, light, and electricity. All these, excepting the last, are known to have chemical actions as their inseparable concomitants. As regards electricity, we have no proof of the dependence of the electrical properties of plants and animals on chemical action. But all the other activities which have been mentioned are fundamentally chemical.

Let us first consider the relation of oxygen to living matter and vital process. Between 1872 and 1876, as the result of an elaborate series of investigations of the respiratory process, the proof was given by Pflüger that the function of oxygen in the living organism is not to destroy effete matter either here or there, but rather to serve as a food for protoplasm, which so long as it lives is capable of charging itself with this gas, absorbing it with such avidity, that although its own substance retains its integrity, no free oxygen can exist in its neighbourhood. The generally accepted notion of effete matter waiting to be oxidised, was associated with a more general one, viz., that the elaborate structure of the body was not permanent, but constantly undergoing decay and renewal. What we have now learnt is, that the material to be oxidised comes as much from the outside as the oxygen which burns it, though the reaction between them, *i.e.*, the oxidation, is intrinsic, *i.e.*, takes place within the living molecular framework.

Protoplasm, therefore, understanding by the term the visible and tangible presentation to our senses of living material, comes to consist of two things—namely, of framework and of content—of channel and of stream—of acting part which lives and is stable—of acted-on part which has never lived and is labile, that is, in a state of metabolism, or chemical transformation.

If such be the relation between the living framework and the stream which bathes it, we must attribute to this living, stable, acting part a property which is characteristic of the bodies called in physiological language ferments or enzymes, the property which, following Berzelius, we have for the last half century expressed by the word catalytic, which we use, without thereby claiming to understand it, to indicate a mode of action in which the agent which produces the change does not itself take part in the decompositions which it produces.

I have brought you to this point as the outcome of what we know as to the essential nature of the all-important relation between oxygen and life. In botanical physiology the general notion of a stable catalysing framework, and of an interstitial labile material, which might be called catalyte, has been arrived at on quite other grounds. This notion is represented in plant physiology by two words, both of which correspond in meaning—Micellæ, the word devised by Nägeli, and the better word, Tagmata, substituted for it by Pfeffer. Nägeli's word has been adopted by Professor Sachs as the expression of his own thought in relation to the ultra-microscopical structure of the protoplasm of the plant cell. His view is that certain well-known properties of organised bodies require for their explanation the admission that the simplest visible structure is itself made up of an arrangement of units of a far inferior order of minuteness. It is these hypothetical units that Nageli has called Micellæ.

Now, Nägeli, in the first instance, confounded the micellæ with molecules, conceiving that the molecule of living matter must be of enormous size. But, inasmuch as we have no reason for believing that any form of living material is chemically homogeneous, it was soon recognised, perhaps first by Pfeffer, but eventually also by Nageli himself, that a micellæ, the ultimate element of living material, is not equivalent to a molecule, however big or complex, but must rather be an arrangement or phalanx of molecules of different kinds. Hence the word Tagma, first used by Pfeffer, has come to be accepted as best expressing the notion.

Now, if we compare Nageli's diagram of micellæ, we shall at once see how it unites itself with the view I gave you just now from the side of animal physiology, of catalysing framework and interstitial catalysable material.

To Professor Sachs, this porous constitution of protoplasm serves to explain the property of vital turgescence, that is, of charging itself with aqueous liquid. To this property the power which the living parts of plants possess of doing external work is no doubt referable—a power which Sachs estimates to be so enormous that living protoplasm may, he believes, be able to condense water which it takes into its interstices to less than its normal volume. To this subject we will return later. For the moment it is sufficient for us to understand that to the greatest botanical thinkers, as well as to the greatest animal physiologists, the ultimate mechanism by which life is carried on is not, as Professor Sachs puts it, "slime," but "a very distensible and exceedingly fine network." For it must be understood that each of the physiologists to whom reference has been made regards the micellæ, not as a mere aggregate of separate particles, but as connected together so as to form a system.

And now let us try to get a step further by crossing back in thought from plants to animals. At first sight, the elementary vital processes of life seem more complicated in the animal than in the plant, but they are, on the contrary, simpler; for plant protoplasm, though it may be structurally homogeneous, is dynamically polyergic—it has many endowments—whereas in the animal organism there are cases in which a structure has only one function assigned to it. Of this the best examples are to be found within so-called excitable tissues, viz., those which are differentiated for the purpose of producing (along with heat) mechanical work, light, or electricity. In the life of the plant these endowments, if enjoyed at all, are enjoyed in common with others.

By the study, therefore, of muscle, of light organ and of electrical organ, the vital mechanism is more accessible than by any other portal. About light organs we as yet know little, but the little we do know is of value. Of electrical organs rather more, about muscle a great deal.

To the case of muscle, Engelmann, one of the best observers and thinkers on the elementary questions which we have now before us, has transferred the terminology of Nägeli and Pfeffer as descriptive of the mechanism of its contraction. Muscular protoplasm differs from those kinds of living matter to which I have applied the term "polygeric," in possessing a molecular structure comparable with that of a uniaxial crystal in this respect, that each portion of the apparently homogeneous and transparent material of which it consists resembles every other.

With this ultra-microscopical structure, its structure, as investigated by the microscope may be correlated, the central fact being that, just as a muscular fibre can be divided into cylinders by cross sections, so each such cylinder is made up of an indefinite number of inconceivably minute cylindrical parts, each of which is an epitome of the whole. These, Engelmann, following Pfeffer, calls ino-tagmata. So long as life lasts each minute phalanx has the power of keeping its axis parallel with those of its neighbours, and of so acting within its own sphere as to produce, whenever it is awakened from the state of rest to that of activity, a fluxion from poles to equator. In other words, muscle, like plant protoplasm, consists of a stable framework of living catalysing substance, which governs the mechanical and chemical changes which occur in the interstitial catalysable material, with this difference, that here the tagmata are arranged like those of a uniaxial crystal, whereas in plant protoplasm there may be no evidence of such arrangement.

According to this scheme of muscular structure, the contraction—*i.e.*, the change of form which, if allowed—a muscle undergoes when stimulated, has its seat not in the tagma, but in the interstitial material which surrounds it, and consists in the migration of that labile material from pole to equator, this being synchronous with explosive oxidation, sudden disengagement of heat and change in electrical state of the living substance. Let us now see how far the scheme will help us to an understanding of this marvellous concomitance of chemical, electrical, and mechanical change.

It is not necessary to prove to you that the discharge of carbon dioxide and the production of heat which we know to be associated with that awakening of a muscle to activity which we call stimulation, are indices of oxidation. If we take this fact in connexion with the view that has just been given of the mechanism of contraction, it is obvious that there must be in the sphere of tagma an accumulation of oxygen and oxidisable material, and that concomitantly with or antecedently to the migration of liquid from pole to equator, these must come into encounter. Let us for a moment suppose that a soluble carbohydrate is the catalysable material, that this is accumulated equatorially, and oxygen at the poles, and consequently that between equator and poles water and carbon dioxide, the only products of the explosion, are set free. That the process is really of this nature is the conclusion to which an elaborate study of the electrical phenomena which accompany it has led one of the most eminent physiologists of the present time, Professor Bernstein. To this I wish for a moment to ask your attention.

Professor Bernstein's view of the molecular structure of muscular protoplasm is in entire accordance with the theory of Pflüger and with the scheme of Engelmann, with this addition, that each ino-tagma is electrically polarised when in a state of rest, depolarised at the moment of excitation or stimulation, and that the axes of the tagmata are so directed that they are always parallel to the surface of the fibre, and consequently have their positive sides exposed. In this amended form, the theory admits of being harmonised with the fundamental facts of muscle-electricity, namely, that cut surfaces are negative to sound surfaces, and excited parts to inactive, provided that the direction of the hypothetical polarisation is from equator to pole, *i.e.*, that in the resting state the poles of each tagma are charged with negative ions, the equators with positive; and consequently that the direction of the discharge in the catalyte at the moment that the polarisation disappears is from pole to equator.

Time forbids me even to attempt to explain how this theory enables us to express more consistently the accepted explanations of many collateral phenomena, particularly those of electrotonus. I am content to show you that it is not impossible to regard the three phenomena, viz., chemical explosion, sudden electrical change, and change of form, as all manifestations of one and the same process—as products of the same mechanism.

In plants, in certain organs or parts in which movement takes place as in muscles in response to stimulation, the physiological conditions are the same or similar, but the structural very different; for the effect is produced not by a change of form, but by a diminution of volume of the excited part, and this consists not of fibres but of cells. The way in which the diminution of volume of the whole organ is brought about is by diminution of the volume of each cell, an effect which can obviously be produced by flow of liquid out of the cell. At first sight therefore the differences are much more striking than the resemblances. Is it so in reality?

The more closely we fix our attention on the elementary process rather than on the external form, the stronger appears the analogy—the more complete the correspondence. The state of turgor, as it has been long called by botanical physiologists, by virtue of which the framework of the protoplasm of the plant retains its content with a tenacity to which I have already referred, is the analogue of the state of polarisation of Bernstein. As regards its state of aggregation, the only fact is that the electrical concomitants of excitation of the plant cell so closely correspond with those of muscle, that it can scarcely be doubted that here also the tagmata are cylindrical, and have their axes parallel to each other. Beyond this we ought perhaps not to allow speculation to carry us, but it is scarcely possible to refrain from connecting this inference with the streaming motion of protoplasm which in living plant cells is one of the indices of vitality. If, as must I think be supposed, this movement is interstitial, *i.e.* due to the mechanical action of the moving protoplasm on itself, we can most readily understand its mechanism as rhythmically recurring, leading to alteration of close and open order in the direction of the tagmatic axes.

To complete this outline, so far as I can to-day, I have but one other consideration to bring before you, one which is connected with the last of my four points of departure—that of the relation of oxygen to protoplasm, a relation which springs out of the avidity with which, without being oxidised or even sensibly allied in chemical constitution, it seizes upon oxygen and stores it for its own purposes. The consideration which this suggests is that if the oxygen and oxidisable material are constantly stored, they must either constantly or at intervals be discharged; and, inasmuch as we know that in every instance, without exception, in which heat is produced or work is done, these processes have discharge of water and of carbon dioxide for their concomitants, we are justified in regarding these discharges as the sign of expenditure, the charging with oxygen as the sign of restitution. In other words, a new characteristic of living process springs out of those we have already had before us, namely, that it is a constantly recurring alternation of opposite and complementary states, that of activity or discharge, that of rest or restitution.

Is it so or is it not? In the minds of most physiologists the distinction between the phenomena of discharge and the phenomena of restitution *(Erholung)* is fundamental, but beyond this, unanimity ceases. One distinguished man in Germany and one in England—Professor Hering and Dr. Gaskell—have taken, on independent grounds, a different view to the one suggested. According to Hering, life consists not of alterations between rest and activity, charge and discharge, loading and exploding, but between two kinds of activity, two kinds of explosion, which differ only in the direction in which they act, in the circumstance that they are antagonistic to each other.

Now when we compare the two processes of rest, which as regards living matter means restitution, and discharge which means action, with each other, they may further be distinguished in this respect, that, whereas restitution is autonomic, *i.e.* goes on continuously like the administrative functions of a well-ordered community, the other is occasional, *i.e.* takes place only at the suggestion of external influences; that, in other words, the contrast between action and rest is (in relation to protoplasm) essentially the same as between waking and sleeping.

It is in accordance with this analogy between the alternation of waking and sleeping of the whole organism, and the corresponding alternation of restitution and discharge, of every kind of living substance, that physiologists by common consent use the term Stimulus *(Reiz, Prikkeling)*, meaning thereby nothing more than that it is by external disturbing or interfering influence of some kind that energies stored in living material are (for the most part suddenly) discharged. Now, if I were to maintain that restitution is not autonomic, but determined, as waking is, by an external stimulus—that it differed from waking only in the direction of which the stimulation acts, *i.e.* in the tendency towards construction on the one hand, towards destruction on the other, I should fairly and as clearly as possible express the doctrine which, as I have said, the two distinguished teachers I have mentioned, viz. Dr. Gaskell and Professor Hering, have embodied in words which have now become familiar to every student. The words in question, anabolism, which being interpreted means winding up, and catabolism, running down, are the creation of Dr. Gaskell. Professor Hering's equivalents for these are assimilation, which, of course, means storage of oxygen and oxidisable material, and disassimilation, discharge of these in the altered form of carbon dioxide and water. But the point of the theory which attaches to them lies in this, that that wonderful power which living material enjoys of continually building itself up out of its environment is, as I have already suggested, not automatic, but just as dependent on occasional and external influences or stimuli, as we know the disintegrating processes to be; and accordingly Hering finds it necessary to include under the term stimuli not only those which determine action, but to create a new class of stimuli which he calls *Assimilations-Reize*, those which, instead of waking living mechanism to action, provoke it to rest.

It is unfortunately impossible within the compass of an address like the present to place before you the wide range of experimental facts which have led two of the strongest intellects of our time to adopt a theory which, when looked at *à priori*, seems so contradictory. I must content myself with mentioning that Hering was led to it chiefly by the study of the examples to which I referred in my introduction, namely, the colour-discriminating functions of the retina, Dr. Gaskell by the study of that very instructive class of phenomena which reveal to us that among the channels by which the brain maintains its sovereign power as superior regulator of all the complicated processes which go on in the different parts of the animal organism, they are some which convey only commands to action, others commands to rest, the former being called by Gaskell catabolic, the latter anabolic.

I have indicated to you that although scientific thought does not, like speculative, oscillate from side to side, but marches forward with a continued and uninterrupted progress, the stages of that progress may be marked by characteristic tendencies; and I have endeavoured to show that in physiology the questions which concentrate to themselvet the most lively interest are those which lie at the basis of the elementary mechanism of life. The word life is used in physiology in what, if you like, may be called a technical sense, and denotes only that state of change with permanence which I have endeavoured to set forth to you. In this restricted sense of the word, therefore, the question "What is Life?" is one to which the answer is approachable; but I need not say that in a higher sense—higher because it appeals to higher faculties in our nature—the word suggests something outside of mechanism, which may, perchance, be its cause rather than its effect. The tendency to recognise such a relation as this is what we mean by vitalism. An anti-vitalistic tendency accompanied the great advance of knowledge that took place at the middle of the century. But even at the height of this movement there was a reaction towards vitalism, of which Virchow, the founder of modern pathology, was the greatest exponent. Now, a generation later, a tendency in the same direction is manifesting itself in various quarters. What does this tendency mean? It has to my mind the same significance now that it had then. Thirty years ago the discovery of the cell as the basis of vital function was new, and the mystery which before belonged to the organism was transferred to the unit, which, while it served to explain everything, was itself unexplained. The discovery of the cell seemed to be a very close approach to the mechanism of life, but now we are striving to get even closer, and with the same result. Our measurements are more exact, our methods finer; but these very methods bring us to close quarters with phenomena which, although within reach of exact investigation, are as regards their essence involved in a mystery which is the more profound the more it is brought into contact with the exact knowledge we possess of surrounding conditions.

If what I have said is true, there is little ground for the apprehension that exists in the minds of some that the habit of scrutinising the mechanism of life tends to make men regard what can be so learned as the only kind of knowledge. The tendency is now certainly rather in the other direction. What we have to guard against is the mixing of two methods, and, so far as we are concerned, the intrusion into our subject of philosophical speculation. Let us willingly and with our hearts do homage to "divine philosophy," but let that homage be rendered outside the limits of our science. Let us, if we are so inclined, cross the frontier and philosophise; but, for my part, as a physiologist I feel more disposed to do my best to furnish professed philosophers with such facts relating to structure and mechanism as may serve them as aids in the investigation of those deeper problems which concern man's relations to the past, the present, and the unknown future.

The presidential address was very heartily applauded, and after completing the reading of it the Acting-President proposed that the best thanks of the section be given to Dr. Burdon Sanderson.

This was seconded by

Sir JOHN LUBBOCK, who said they must all regret the absence of their president, and more particularly when they knew that it was caused by illness. The address to which they had just listened was a most interesting and suggestive one. It could not fail to impress those who read it with the fact that people were in the habit of speaking of animals and plants without any very definite notion of what they meant. It was not only the physical difficulty of the case, for we all knew from the very imperfections of our microscopes and of our own eyes, even from the character of light itself, that it was beyond our power at present to arrive at any exact ideas concerning the construction of the biological organism. The whole of the questions involved were of enormous complexity, and their solution awaited the labours of biologists such as Dr. Burdon Sanderson, whose address that day deserved to be regarded as a most valuable contribution to the science.

REPORTS OF COMMITTEES.

The section then proceeded with the consideration of the reports submitted by various committees.

Professor Newton reported the steps which had been taken for the investigation of the natural history of the Friendly Islands, and in other groups in the Pacific. Mr. Lister, who had been entrusted with the commission, was on board H.M.S. Egeria, and would pursue his researches wherever that vessel called.

The committee, with Professor Flower for its chairman, which was first appointed in 1887 for the purpose of reporting on the zoology and botany of the West India Islands, presented its second report. The zoological specimens obtained up to June last had been placed in the hands of specialists for examination and determination, and the botanical specimens collected up to May had been determined at Kew. The number of novelties was hardly so great as had been expected, which might arise either from the ground having been worked before, or more probably from the fact that a considerable uniformity prevails in the flora of this chain of islands, with a corresponding paucity in endemic types.

The committee appointed to investigate the development of the oviduct of certain freshwater teleosti reported that they had been unable to carry out their inquiry, owing to inability to obtain ova and fry of the special fish required for the purpose. The committee on the disappearance of native plants reported:—The attention of correspondents has been in the main confined to complete or threatened extinction; but in addition to this there is a general consensus of opinion that the rarer and more conspicuous Alpine plants are less abundant than they used to be. Most of the correspondents agree that the injudicious action of botanists themselves, and of botanical exchange clubs, has been a potent factor in the changes which have taken place. It is too often forgotten that the very rarity of a plant is the sign, and in great degree also the measure, of the acuteness of its struggle for existence, and that when a plant is in a state of unstable equilibrium with its environment a small disturbance may have disproportionately great effects.

The committee feels, however, that neither local dealers nor their customers are as a rule amenable to any ordinary appeal or to sentimental considerations, and would suggest, therefore, that the local Natural History Societies or Field Clubs should keep careful guard over any rare plants to be found within their respective spheres of action, and by appeal to the owner, or in other preferable way, should endeavour to effect their preservation.

A report was presented by the committee on the zoological station at Naples.

The committee appointed to make observations on the migration of birds reported that one of their number, Mr. W. Eagle Clarke, of the Museum of Science and Art at Edinburgh, had undertaken to prepare the digest of the observations; and all the materials for making the same, including 1,500 skeleton maps of the British Islands, provided for the purpose, have accordingly been placed in his hands.

An interesting report was presented from another committee on the subject of the flora of China.

The members then adjourned for luncheon, and on resuming the section divided itself into two departments, one dealing with zoology, and the other, which met in an adjoining room, dealing with botanical subjects.

ZOOLOGICAL DEPARTMENT.

In this department Canon Tristram presided.

FAUNA OF THE LOUISIADE ISLANDS.

Mr. **Basil H. Thomson** read some notes on the fauna of the Louisiade and d'Entrecasteaux Islands. An official expedition was made in October last to these islands in order to open communication with the natives on behalf of the Colonial government of Sydney. The paper enumerated the more remarkable of the Lepidoptera, Orthoptera, Coleoptera, and land molluses of the islands, and described the distinctive physical characters of each island.

AVIFAUNA OF THE CANARY ISLANDS.

The Rev. Canon **Tristram** contributed a paper on peculiarities of the avifauna of the Canary Islands, the result of observations made by himself and two friends during two visits to the Canaries. In the course of his paper he said the seven islands which form the Canary group naturally divide themselves into two groups—1st, Lanzarote and Fuertaventura, those nearest the African continent, and which may be looked upon as insular outlines of the Sahara; 2nd, the other five islands, Canaria, Tenerife, Gomera, Palma, and Hierro. The first group are slightly elevated plateaus with a completely surrounding fringe of low volcanic hills, and are destitute of timber and almost so of water. The birds are all identical with or closely allied to those of the Sahara, notably, *Otis honbara*, *Pterocles arenarius*, *Cursorius gallicus*, *Pyrhula githaginea*, *Calandella minor*, *Parus ultramarinus* var. Only one peculiar species has been found—*Pratincola dacotia*. The only peculiar Canarian species which occurs is *Anthus berthelot*. The second group are much more varied in their avifauna. In only three of them, Tencrife, Gomera, and Palma, is there any extent of natural forest. This extends generally from 3,500 feet to 5,000 feet in height. In these forests only most of the peculiar species are found, especially the two species of pigeon—*Columba lauridora* and *Cibollii*—the former in two, the latter in all three of the forested islands. Their distinctive habits are described. Of the chaffinches there are three species; one *Fringilla tintillon* found in Canaria, Tenerife, and Gomera. Another *Forteydca* peculiar to Tenerife; and a third, *Fr. palmæ*, peculiar to Palma. The titmouse of three islands is *Parus tenerife*, which can always be discriminated from *P. ultramarinus*. In Palma is a third very distinct species, *Parus palmensio*. The only peculiar bird which seems common to all seven islands is *Anthus bertheloti*. In Canaria *Caccabis rufa* is common, in Tenerife and Gomera *C. petrosa* takes its place. In Palma there is no partridge. Quails are found in all the islands. The cornish chough abounds in Palma, to which it is exclusively confined. The woodcock is a permanent resident in three of the islands. The peculiarities of the forests were described, and the paper endeavoured to show the connexion of the variation of the avifauna with with the geological history of the group.

PALLAS'S SAND GROUSE.

Professor **Newton** stated that, having on two former occasions (1863 and 1888) drawn attention to the irruptions of *Syrrhaptes peradoxers*, Pallas's sand grouse, he now had to introduce it to notice as a native of Britain, and exhibited a specimen not more than two or three days old which had been caught in the north of Scotland on the 8th of August last, and was, he believed, the first example of the bird at that age which had been seen by naturalists.

ABNORMALITIES IN FISHES.

Professor **Windle** addressed the section on certain congenital abnormalities in fishes, and also on the morphology of the long flexors of the digits of the mammalian hand, illustrating his remarks by blackboard diagrams.

FRESHWATER ANNELIDS.

Mr. **Frank E. Beddard**, M.A., of the Zoological Society, of London, contributed a paper on this subject, in which he pointed out that, in spite of the labours of Claparède, D'Udekem, Perrier, Vejdovsky, and Stolç upon the continent, and of Lankester, MacIntosh, Bousfield, and others in this country, a good deal remains to be done before we can claim to have a satisfactory knowledge of even the British freshwater Oligochæta, while the exotic forms, except those studied by Leidy and Eisen in America, are at present almost entirely unknown. Having lately had the opportunity of studying some New Zealand "Limicolæ," through the kindness of Mr. W. W. Smith, of Ashburton, Mr. Beddard was enabled to offer some remarks upon them, and also upon some little known British species.

Mr. **Beddard** also described the cœca of South American Tinamon.

FOOD FISHES.

Professsor **McIntosh**, F.R.S., head of the Marine Laboratory at St. Andrews, read the papers. The first of these was on the tarpon, or silver king, of Florida, a very fine example of which was shown to the meeting, having been sent by Lady Playfair, wife of a former president of the association. A general account was given of its external appearance and its habits were pointed out. The second paper dealt with the eggs of the sole, and the fact that hitherto these had not been hatched in any laboratory in this country. The young sole was one of the hardiest of marine fishes, making it a very simple experiment to increase its number. The lecturer showed the remarkable transformation it underwent in colour as it grew older. The larval spratt was also described, and its difference from the herring described. Other food fish were also spoken of, and Prof. McIntosh in his third paper described some new and rare forms which had been observed at the St. Andrew's laboratory, amongst others a *heteropod*, which was described as a kind of shell fish.—Some little discussion followed on the reading of the papers by Canon Norman and Mr. Woodall, formerly Mayor of Scarborough, a number of gentlemen hoping that when the fishery boards came to be established in connexion with the new local governing bodies, they would profit by the work which had been done by Prof.

McIntosh at St. Andrews, and also at the Plymouth laboratory.

This concluded the day's proceedings in the zoological department.

BOTANY.

Prof. S. H. VINES, of Oxford, presided over the subsection devoted to botany, to which some instructive papers were contributed.

Mr. J. G. BAKER read a paper on the occurrence of *arenaria norvegica* in Yorkshire; Prof. F. O. Bower, "On the meristem of ferns as a study in Phylogeny"; Prof. Hartog, "On the structure of the nucleus in *saprolegnia*"; Mr. H. Wager, "On the structure of the nuclei in *peronspora parascitica*"; and Mr. A. W. Bennet a couple of papers, one "On the antherozooids of cryptogams," and the other "On hybrid desmid."

SECTION E.—GEOGRAPHY.

President:—Colonel Sir Francis de Winton, K.C.M.G., F.R.G.S.

Vice-Presidents:—General Sir H. E. L. Thuillier, R.A., C.S.I., F.R.S., F.R.G.S.; R. Spence Watson, LL.D., F.R.G.S.; J. Batalha-Reis.

Secretaries:—J. S. Keltie, F.R.G S. (Recorder); H. J. Mackinder, M.A., F.R.G.S.; H. N. Sulivan, F.R.G.S.; A. Silva White. F.R.S.E., Sec.R.Scot.G.S.

Place of meeting, St. James' Schools.

ADDRESS BY SIR FRANCIS DE WINTON.

The President said:—Geography has not inaptly been defined as "the science of distributions," and from whatever aspect we view it, whether from a large and comprehensive basis embracing all the conditions which surround it as a science, or from the narrower limits of simple physiography, we find certain well-defined principles, or one may term them natural laws, pervading everywhere, whose actions have, through their influences on the past, created the present, and according to the uses we now put them must largely govern the future. It matters not how rapidly you travel from the pole to the equator, you will freeze at the one and perspire at the other; and while passing through the different zones of temperature lying between these regions—the frigid, temperate, and torrid zones—you will find each with their own products, varying with climate, soil, and peculiarity of position, and these variations pervade the whole realm of nature. The

EFFECT OF CLIMATE UPON RACE

is somewhat remarkably illustrated in recent times by noticing the physique and nerve-power of the present race of Americans. The wonderful tide of emigration which has raised them to being a nation of 60,000,000 people may have exercised certain influences as regards this change; but there are many true Americans still in existence. Two hundred years ago they were the same race as ourselves, but the difference between us now is marked. The climate of America has given them an individual stamp, and a perceptible difference in outward semblance has shown itself even in this short space of time. Similar changes are manifested throughout the whole animal and vegetable kingdom. I shall endeavour to draw attention to the great necessity for a more thorough study of the science

APPLIED GEOGRAPHY.

and the influence it exerts upon trade and commerce, as we gain a better knowledge of the products of one country and the industries of another, as well as the importance of such knowledge to the great manufacturing centres of this nation as new countries are discovered and developed. It must be remembered we no longer enjoy a monopoly of trade. Largely the rise and fall of the great emporiums of commerce in past centuries were influenced by the struggle for the Eastern trade. This struggle is still going on. The Russians in Central Asia are steadily advancing as each year goes by, and developing that system of absorption which has characterised their policy, especially in that region. There is no doubt, since the completion of the Trans-caspian railway to Samarcand, a great impetus has been given to Russian trade in Central Asia, even extending, by well-known routes, as far as the north-west provinces of China, where Russian goods are now found entering into competition with those of English manufacture. By means of this railway, right into the heart of Asia, Russia has obtained the trade of a vast area, which formerly passed entirely through British hands. Both politically and commercially she is our rival in the East, and the question which nation is to be supreme must come sooner or later. Our knowledge of the latest acquisition in the East, Burmah, has been largely increased during the past eighteen months. Important surveys in North-Eastern Burmah by Colonel Woodthorpe, R.E., and Mr. Ogle have opened up an area of about 1,500 square miles; and the fact of practicable routes between Assam and Burmah *via* the Palka Pass is now established. Burmah, with its large and intelligent population (numbering about 4,000,000), with its valuable minerals and precious stones, with its tropical products, is well worthy of the attention of the merchant adventurer; and as our knowledge of the physiography of the country is rapidly increasing, a study of its applied geography is strongly recommended to the student. Turning to the northern parts of Asia, I feel some diffidence in speaking before a Newcastle audience on the subject of Siberia, for through your own townsmen, and

CAPTAIN WIGGINS,

you are well acquainted with these regions. The exertions made by Captain Wiggins and those connected with him in this enterprise should receive the highest commendation; and that they have been so far successful is a matter for rejoicing. At the same time, I cannot but think that Russia, continuing the policy she has so steadily pursued for some years past, against the commercial development of Great Britain, would not object to the employment of British capital in opening up trade in her outlying dominions; for that trade, once fairly established on good business lines, would be absorbed on behalf of her own manufacturers. I do not attach any blame to Russia in this matter, but I am of opinion that more profits are to be gained when trade follows the flag, for then British enterprise and money reap more certain reward. If the energy, talent, and perseverance which have been exhibited by Captain Wiggins and his partners had been utilised in the development of some of our own territories rather than in the territory of another nation, I feel sure they would command that success to which they are so justly entitled. From the consideration of Siberia and the Northern Seas it is not a far step to Greenland, whose icy regions and eternal snows have been crossed for the first time in our history. The hero of this exploit,

DR. FRIGHTOF NANSEN.

is a native of Norway, and the exploration which he has so recently conducted to a successful issue was rightly alluded to by the President of the Royal Geographical Society, in his annual address, as the most conspicuous achievement of the year. Though young in years, Dr. Nansen proved himself to be a leader of men, and the account of his adventures will be found to be full of interest. Crossing from Greenland to North America, we still find ourselves in regions where ice and snow hold undisputed sway for a considerable portion of the year. The Canadian Government, with commendable activity, keep pushing forward their surveys into what is known as the Old Hudson Bay Territory. The Mackenzie River has been found to be a far larger body of water than formerly supposed. More accurate surveys as regards the size of some of the great lakes of those regions are being made, and our knowledge of the climate and the isothermal variations of British North America is each year increasing. Petroleum has been discovered, and, as the geological surveys advance, other discoveries of an important nature may reasonably be anticipated. I have been told of the existence of a huge bed of porous sandstone, saturated with mineral oil, which burns like coal. Moving southwards, we pass through the prairie-lands of the

North-West of Canada, traversed by the Canadian Pacific Railway. These rich lands are being rapidly developed, and should form a happy home for some of our surplus population. Colonisation is a subject full of geographical considerations, but it demands a special paper, and I have neither space nor time to introduce it into this address. At the western edge of these prairie-lands are the Rocky Mountains, in whose foot-hills are now being reared large herds of cattle and horses, as well as flocks of sheep. Some cattle from these fertile regions were shipped last year to the English market, and no doubt a regular trade will soon follow this experiment. In Australasia, with its six great colonies of Queensland, Victoria, New South Wales, South Australia, Western Australia, Tasmania, to which may be added New Zealand, virgin fields untrodden by the foot of white man are still awaiting the explorer to yield up their treasures to the science of applied geography; and when the marvellous progress that has been made in a few short years by our Australian colonies is weighed and considered, and as its vast interior is opened by exploration, and its mineral resources are developed, who could venture to predict the future that lies before it? Last but not least in this record of geographical progress of the world is the vast continent of Africa. As regards Africa

TWO VERY REMARKABLE JOURNEYS

have recently been brought to a successful conclusion—that of Count Teleki, an Austrian, on the north, and that of Mr. Arnut in the regions south of the equator. The former, entering Africa at Mombasa, at the head of a numerous and well-equipped caravan, passed through the Masai country by what is known as Thompson's route, and, pushing northwards, discovered Lake Rudolph, a large inland salt lake, and by following its shores he was enabled to trace with commendable accuracy its shape, size, and position. The existence of a large lake, called Samburu, in the direction of Count Teleki's journey, had for some time been spoken of by the Arabs who traded in that region, but nothing definite was known concerning it. Count Teleki also obtained much valuable information of the region between Mount Kenia and Lake Rudolph, its inhabitants, its rivers, and its products; and the details of his most interesting and successful journey have yet to be published. Mr. Arnut, on the other hand, started in 1883 from Pietermaritzburg with a very slender equipment and hardly any following. His object was to prove the existence of healthy plateaus in the interior of Africa where white men could live and prosecute the work of missionary civilisation without being exposed to the malarial influences which exist in so many parts of Central Africa. Taking a northerly course, he reaches the Zambesi, whose waters he follows as far as Lealui. From this point his route trends to the west as far as Robongo, the capital of the Bihe country. From Robongo he continues his march to Bailundu, and from thence he reaches Benguela, on the west coast. Thus he crossed Africa in the same direction as Livingstone's first journey, though somewhat to the south of Livingstone's route. While at Bailundu he meets some messengers from Msidi, the chief of the Garengenze country, who beseech him to visit their king; and having replenished his stores, he retraces his steps to the interior. From January, 1885, to February, 1886, he perseveres in his attempt to reach the capital of Msidi's country, and his efforts are at length crowned with success. After a sojourn among these people for two years, during which time he thoroughly succeeded in obtaining their confidence and that of their ruler Msidi, he returned to Europe in the latter part of last year, but not before he had established two other white missionaries at Mukururu to continue the work he had begun. He also made several small expeditions during his residence at Mukuru, the most interesting of which was to the cave-dwellers of Urua mentioned by Livingstone. This kingdom of Garengenze is situated to the east of Lake Moero; and Mr. Arnut has recently published a book of his travels, giving a very clear and interesting account of these people, their manners, and their customs. Of all Livingstone's followers, Mr. Arnut very closely resembles the great leader in the patient earnestness, the quiet energy, and the scanty resources with which he prosecuted his remarkable journeys. The events which attended the expedition under Mr. H. M. Stanley to succour and relieve Emin Pasha are well known to you all. The value of

MR. STANLEY'S JOURNEY

and the remarkable energy and courage he displayed, his high scientific attainments, and the information that will result from his labours, are, from a geographical point of view, of the highest interest. The desiccation of the lake Albert Nyanza, and its influences on the rise and fall of the Nile, is not the least remarkable of these problems. For my own part, I am of opinion that this rise and fall is mainly caused by the rapid growth of tropical water-plants. During the dry season this vegetation increases enormously, and at the first rains large masses of aquatic growth are loosened by the rising of the waters. These masses, in the form of floating islands, pass downwards on the bosom of the flowing waters, and on reaching a wide and shallow part of the river, such as we find at Bahr-el-Ghazal, they gradually but quickly collect till they form a dam of sufficient density to obstruct the progress of the river; and the water thus arrested finds a temporary lodgment in the lake Albert Nyanza, causing it to overflow its normal boundaries. At length the vegetable dam can no longer withstand the weight and pressure of the water bearing upon it; a portion gives way; a channel is opened; and the river, hurrying on to the sea, overflows the banks of the Lower Nile and drains the lake to a lower level. This is what happens to the Albert Nyanza, which is nothing more than a huge backwater of the Upper Nile basin, and it accounts for the lake being seen at two different levels by those two distinguished explorers, Mr. H. M. Stanley and Sir Samuel Baker, and hence the difference of opinion as to its true extent and size that has arisen between them. We know that this phenomenon takes place on Lake Tanganika, as Stanley found a marked difference in its level on the two occasions he rested upon its shores. He also followed the Lakuga River from the Tanganika lake to its junction with the Congo; and there is no doubt that a vegetable dam, such as I have described, forms at the point of dedarture of this river from the lake, and prevents its regular flow till the weight and pressure behind it sweeps all away. During the second year that I was on the Congo we had an unusually heavy flood at the time of the first rains. The river rose several feet in one night, and some months afterwards news came from the Upper Congo that the waters of the big lake had broken through, and this no doubt had reference to the Lukuga River and Lake Tanganika. Now, as regards the countries through which we have been passing, there are certain points of great interest connected with the science of applied geography, to which I desire to draw your special attention. The first of these points is the study of the great railway systems of the world, and the application of railways to the development of new countries. Take our Indian possessions for example. What a change has been wrought, not only as regards the commerce of the country, but also with reference to the social condition of its inhabitants and their manners and customs! The introduction of Indian wheat, by means of these railways, into the markets of Europe has caused a revolution in the trade of that commodity. We find this especially in America, where it has upset the calculations of those gigantic combinations or rings which sought to obtain a monopoly in the supply of this universal article of food. Thus the construction of railways in the East exercises commanding influences over the markets of the West. The Congo Free State has wisely determined to build a railway, of some 250 miles in length, to cross the cataract region; and the moment it is completed the future of that country is assured. H.M. the King of the Belgians has kindly given permission for a Belgian officer of distinction, Captain Thys, to read a paper at this meeting on the railway, which will afford a more detailed account of this wise and patriotic undertaking. As I remarked at the beginning of this paper, the discovery of steam as a motive power has brought the world into an extraordinary condition of contactiveness, and quite recently several new companies have been formed in the same spirit and on the same lines as those followed by the old merchant adventurers. These later creations are being started under more favourable conditions than their predecessors, for they have all the advantages which modern science and modern appliances can afford. The English Government have wisely encouraged and promoted the formation of these trading corporations. In countries where climate and circumstances of environment are not favourable to colonisation by white men, our colonial system of government progresses somewhat slowly. It has not the elasticity, nor the adaptability, to provide for the many contingencies which must naturally arise when a few white men maintain the position of rulers over large areas peopled by savage and uncivilised races. In the island of Borneo there is the North Borneo Company trading, governing, and civilising a large portion of territory with marked success. On the west coast of Africa, the Royal Niger Company is developing the great natural resources of that magnificent river, and its tributary the Binue. On the east coast there is the Imperial British East African Company, operating in what is known as the British sphere of influence north of Zanzibar. Though not a twelvemonth has passed since they commenced their work, their initiatory proceedings have been remarkably successful, and there is every prospect of an early and rapid development of the territory committed to their charge. In the south-eastern portion of Central Africa, the African Lakes Company have fairly established themselves ; and a new company is now being formed to open up and civilise a further portion of that section of the African continent. The establishment of these great trading and governing centres is likely to exercise most important influences. They are, as I have before pointed out, from their organisation and objects, better adapted at the outset to compete with and overcome the obstacles which present themselves to established forms of bureaucratic government; at the same time the Government of this country can interfere, in cases of necessity, by the grants that have been made to them of royal charters, under which they carry on their operations. A wise control and judicious administration combined with the introduction of commerce and civilisation, will, at no distant date, open these territories to the markets of the world, to the missionary, and to the scientific explorer. The commercial element of geography also enters very largely into their promotion and prosperity because of the fields they open to our home manufactures. It is important here to observe that, if these territories had passed into the hands of other nationalities, but a very limited quantity of British goods would ever have entered into them, and their value, as a market for the industries of the nation, would have been lost. The establishment of a Geographical Society in this city is of real importance. Its objects should be the collection of information, and the study of applied geography in all its varied branches and aspects. It should aim to furnish complete information concerning the geography of all parts of the globe. In Chambers of Commerce our large trade centres have, no doubt, means of guiding and controlling some of our most important mercantile operations, but they afford no opportunities to the student, they are not a teaching body ; and there are instances where considerable risks have been incurred and heavy losses sustained in some of their ventures, simply from a want of knowledge of geographical data. I should like to see a Geographical society in every large city of this Empire, conducted on the lines I have briefly suggested, because the study of, and interest in, the commercial geography of this great Empire and the world is too much neglected amongst us. Past prosperity, and a tendency to run in the same groove, narrow our commercial horizon. Slowly but surely other nations, competing with us in many parts of the world, are doing so successfully because of the study they make of commercial geography. It is for this reason I have in my address dwelt strongly upon the question and study of geography as an applied science, and it is for a greater reason I urge its importance, viz., that we may hand down to our children unimpaired the heritage bequeathed us by our forefathers ; a heritage gained by courage, energy, perseverance, and patriotism—qualities which, under God's blessing, have made this nation the head of the commerce of the world. At the close of his address the president introduced some remarks with reference to Mr. H. M. Stanley, which he had omitted from the original copy in the hope of receiving news of the explorer. He said : Last April a report came down to Zanzibar that Mr. Stanley and Emin Pasha had arrived at the north-east corner of the lake Victoria Nyanza, that Mr. Stanley had left Emin Pasha some 15 days before, and had come down to the Ururu country. There he gave a letter to a trader, which letter has never arrived ; but the trader sent a message to the coast of Zanzibar that he had seen Mr. Stanley. This letter not having arrived, I do not consider the news as reliable that he has arrived with Emin Pasha at the north-east corner of the Lake Victoria Nyanza. Still, I believe that Stanley is working his way in the direction indicated by this trader, and I believe that at any moment we may receive intelligence of his successful return to the East Coast of Africa. (Cheers.)

A vote of thanks to the President for his address was moved by General Sir H. E. L. THUILLIER, F.R.S., seconded by Dr. R. SPENCE WATSON, and unanimously accorded.

CYPRUS.

The first paper was one by Sir Robert Biddulph, G.C.M.G., on "Cyprus." Sir Robert Biddulph in the course of his paper dwelt at considerable length on the question of the destruction of forests in the island of Cyprus. He said that Cyprus was anciently clothed with forests, and in Old Testament times much shipbuilding took place. In Balaam's prophecy it was stated that "ships shall come from the coast of Chittim," and it was with Cyprus timber that Alexander the Great built the fleets which he launched on the Tigris and Euphrates. At the present time, the forests were confined ranges, and threatened to disappear altogether. At the time of the Egyptian occupation of Cyprus, vast quantities of timber were cut down and carried to Egypt. At the time of the British occupation, the ravages of the wood-cutter were to be seen in full operation, and it could not be doubted that it was only a question of time when the last remaining forests of Cyprus should disappear entirely. The destruction of the forests dated from modern times. The Venetians took immense quantities of timber for their commerce and marine, and the working of mines in Cyprus must also have done great injury to the forests ; but the greatest enemies of forests in every country where they existed were goats. The manner in which the destruction of forests by goats was accomplished had been described by Darwin and others with regard to the island of St. Helena. The question of forests in Cyprus was a very serious one, because it very sensibly affected the wealth and productiveness of the islands. As the forests disappeared, so did the soil that covered the hills. That soil was washed down to the plains, choked the river beds, and formed malarious swamps ; the hills became bare rocks, incapable of growing a blade of grass, and the locusts at once took possession of the barren ground, whilst the absence of trees deprived the earth of its annually fertilising agent, leaf mould. It was only since the forests were destroyed that the locusts had made head in the manner which was so notable in modern times. It was not likely that the great breeding grounds of the locust would ever again be clothed with forest, and the disappearance of the locust must be looked for when the population increased, and with it the cultivation. The population of Cyprus was at the census of 1881 186,000, of whom one-fourth were Mohammedans and the remainder of the Greek Church. The people were almost entirely agricultural, the principal products being wheat, barley, cotton, olives, and grapes. From the last-named was made an excellent wine which had been famous from the earliest ages. The agricultural operations were carried on in a most primitive manner, and the wine was manufactured in the rudest way.

The agricultural prosperity of Cyprus was a matter of the greatest interest to the Government for on that prosperity the revenue entirely depended. The island was emphatically a land of peasant proprietorships, with the result that there were no wealthy persons and no beggars. The houses were poor, exhibited but little architectural skill or beauty, and were mostly built of sun-dried bricks; the villages usually contained from twenty to eighty houses, and there were but few considerable towns. The principal of these was the capital, Nicosia, situated in the central of the island, and having 12,000 inhabitants.

THE CONGO RAILWAY.

The next paper was one by Captain Thys, a Belgian officer, on the subject of "The Congo Railway." The paper was read by the president in English, after the author had addresed a few remarks to the meeting in French.

Dr. H. R. **Mill**, D.Sc., F.R.S.E., read the next paper, which was on "The Physical Basis of Commercial Geography." An abstract of the paper is as follows :—

A necessary preliminary to the study of commercial geography is a full acquaintance with topography, especially with the names and positions of all commercial towns. A necessary accompaniment to the study of commercial geography is a knowledge of the ever-varying relations between regions of supply and demand, the incidence of tariffs, and the political and social conditions of countries. The physical basis of commercial geography, which underlies and gives unity to the whole subject, is a knowledge of the resources of the earth as regards the various existing forms of matter and modes of energy, the best means of separating, combining, and modifying these so as to produce commodities, and the way in which commodities can be best transported. Commerce being the artificial redistribution of the matter and energy of the world, a knowledge of the general properties, and the unchangeable laws of matter and energy, should take a chief place in the training of commercial men. A general acquaintance with this practical science, which may be termed *Applied Physiography*, or *Practical Earth Knowledge*, ought to be possessed by all merchants, and a special branch should be familiar to each. Amongst the advantages which would thus be gained are :—

(1.) The merchant would understand the principles of the production and manufacture of his goods. 2.) He would know in many cases, without aimless and extravagant experiments, where it is possible to produce any special commodity in great abundance. (3.) He could, to a great extent, anticipate the frequent change in staple commodities by knowing what other commodities it is possible to produce in the regions now yielding the staple only. (4.) He would understand the best and shortest routes between trade centres. Illustrations and arguments showing the importance of these statements are given in the paper, and a large map of the commercial development of the world was shown.

A short discussion followed the reading of the paper. Mr. Mackinder, M.A., protested against the attempt to teach commercial geography until the broad principles of non-commercial geography had been taught, and Mr. Sutherland followed on similar lines.

UGANDA.

The Rev. R. P. **Ashe** read a paper on Buganda (Uganda). Geographical investigation included much more than the merely physical features of any country. Speke's discovery of the source of the Nile was hardly so wonderful as his bringing to light the nations and kingdoms about the shores of the Victoria Nyanza. Events of recent years add a deepening interest to Buganda. The author referred, among other matters, to Livingstone's death, Stanley's travels, the Nyanza mission of the Church Missionary Society, Gordon's death, and Stanley's effort to relieve Emin (surviving Egyptian pasha); the English and Germans competing for this market for European manufactures, and key to the lake regions. He then went on to describe the great lake and its islands; tropical forest scenery; the contrasts between Buganda and districts further south; the nature of country; the products of the soil; roads; villages; buildings. As to the people, the author pointed out that the non-negro element is derived from the royal Bahuma (Wahuma) tribe. He then described the Bahuma; referred to the great native, slave, and cattle raids; the organisation of the Buganda people, kings, chiefs, peasants, slaves, manners, and customs. He then spoke of the African problem; the Arab trader; slaves; ivory; guns.

WEST AFRICA.

Mr. **Alfred Moloney**, C.M.G., Governor of the British Colony of Lagos, West Africa, read a paper on the commercial geography of the Yoruba country, West Africa, in the course of which he said that it should never be lost sight of that in primitive countries such as are embraced within and adjourn our West African colonies, it was the duty of the Government to initiate, as regarded advertising, the capabilities of the country represented by its products. The people were industrious in their own fashion, and, although their present wants were small, they were ready to follow examples set, and to develop industries and tastes when once they had been informed thereon, and had learnt to appreciate their value. We wanted new staples of trade, and larger area of demand for our wares; such could only be obtained by restoring trained negroes to their country, by developing local resources, and by introducing alien botanical products suitable for growth in West Africa, and of later marketable value. Our "eggs in one basket" policy must be discontinued. Towards such an end a botanic centre had been established in the colony of Lagos for the education of the native in the direction of recognising the botanical wealth of his own country, and to serve as a distributing centre of economic plants of commercial value, for on its indigenous and exotic agricultural development, must the future of tropical Africa for many years depend.—The President said that from his own experience he fully agreed with what Mr. Moloney had said of the West Coast of Africa. The negro race had to become accustomed to, and to gain confidence in Europeans, and then it was possible to do a great deal of good with them, chiefly by teaching them labour. The true means of overcoming slavery was by teaching the natives the value of labour.

SECTION F.—ECONOMIC SCIENCE AND STATISTICS.

President :—Professor F. Y. Edgeworth, M.A., F.S.S.

Vice-Presidents :—Stephen Bourne, F.S.S.; Hon. C. W. Fremantle, C.B.; G. W. Hastings, M.P.; Professor H. Sidgwick, LL.D.

Secretaries :—Rev. W. Cunningham, D.D., D.Sc., P.S.S.; T. H. Elliott, F.S.S. (Recorder); F. B. Jevons, M.A.; L. L. F. R. Price, M.A., F.S.S.

Place of meeting, the Presbyterian Church, Gresham Place.

ADDRESS BY PROFESSOR F. Y. EDGEWORTH.

Prof. F. Y. Edgeworth, the president of this section, dealt in his address with the points at which mathematical reasoning is applicable to political economy. He named them as follows :—A. Perfect Competition : 1, Simplest type of market; 2, complex system of markets, simplified by certain abstractions; 3, the more concrete problem of an exchange and distribution. B. Monopoly: 1, Transactions between a single monopolist and a competing public; 2, transactions between two monopolists or combinations. The use of these applications of mathematics to political economy illustrated by comparison with—1, Applied mathematics generally; 2, the mathematical theory of statistics. In the course of his remarks, he said: At the meeting of the British Association, which was held at Cambridge about a quarter of a century ago, Jevons submitted to this section a "general mathematical theory of political economy." which, as he himself records, was "received without a word of interest or belief." I propose to consider the justice of the unfavourable verdict which our predecessors appear to have passed on the mathematical method introduced by Jevons. The cardinal article of

JEVONS'S THEORY

is that the value in exchange of a commodity measures, or corresponds to, the utility of the least useful portion of that commodity. What a person pays per month or year for a sack or ton of coal is not what he would be willing to give for the same rather than be without fuel altogether. Rather the price is proportioned to the advantage which the consumer expects from the portion which he could best dispense with—to the "final utility," in Jevons's happy phrase. The idea of reducing human actions to mathematical rule may present itself to common sense as absurd. One is reminded of Swift's "Laputa," where the beef was cut into rhomboids and the pudding into a cycloid, and the tailor constructed a very ill-fitting suit of clothes by means of rule and compasses. It should be understood, however, that the new method of economical reasoning does not claim more precision than what has long been conceded to another department of science applied to human affairs, namely, Statistics. It is now a commonplace that actions such as suicide or marriage, springing from the most capricious motives, and in respect of which the conduct of individuals most defies prediction, may yet, when taken in the aggregate, be regarded as constant and uniform. The advantage of what has been called the law of large numbers may equally be enjoyed by a theory which deals with markets and combinations. The use of a curve introduced by Cournot to represent the amount of a commodity offered, or demanded, at any particular price, supplemented by Jevons's theory of final utility, does not, indeed, determine what price will rule in any market. But it assists us in conjecturing the direction and general character of the effect which changes in the condition or requirements of the parties will produce. For example, in the case of international trade, the various effects of a tax or other impediment, which most students find it so difficult to trace in Mill's laborious chapters, are visible almost at a glance by the aid of the mathematical instrument. It takes Professor Sidgwick a good many words to convey by way of a particular instance that it is possible for a nation, by a judiciously regulated tariff, to benefit itself at the expense of the foreigner. The truth in its generality is more clearly contemplated by the aid of diagrams, such as those employed by the eminent mathematical economists, Messrs. Auspitz and Lieben.

ECONOMIC EQUILIBRIUM.

In considering any concrete instances, it is hardly possible to keep to what may be called the simplest type of supply and demand, the ideal market in which we contemplate only two groups of competitors and only two articles of exchange: say, gold for corn, or any other *quid pro quo*. In general, and especially when considering what rates of exchange tend to rule in an average of transactions, it is proper to take into account that the dealings in one market will affect those in another. If the *entrepreneur* has less to pay for machinery, *cæteris paribus*, he will be able to offer more on the labour market. Thus we obtain the idea of a system of markets mutually dependent. In a general view of this correlation it is not necessary to distinguish whether the state of one part is connected as cause or effect with the other parts of the system. As Professor Marshall say:—"Just as the motion of every body in the solar system affects and is affected by the motion of every other, so it is with the elements of the problem of political economy." This conception of mutually dependent positions is one in which minds disciplined in mathematical physics seem peculiarly apt to acquiesce. In other quarters there may be observed a restless anxiety to determine which of the variables in a system of markets is to be regarded as determining or regulating the others. In one of the principal economic journals there has lately been a pretty stiff controversy on the question which of the parties in the distribution of the national produce may be regarded as "residual claimants upon the product of industry"; whether it is the working class which occupies this preferential position, or if the "real keystone of the arch" is interest. Such questions certainly admit of a meaning, and probably of an answer. But they will probably appear of secondary importance to those who accept, as the first approximation to a correct view of the subject, the principle of mutual dependence—what may be called the Copernican theory of distribution, in which one variable is not more determined by another than the other is by that one. Among the factors of this economic equilibrium I have not as yet explicitly included cost of production, Rather, the system of markets which so far I have had in view is that which would arise if all the articles of exchange were periodically rained down like manna upon the several proprietors, and each individual sought to maximise his advantage according to the law of final utility. But now we must observe that self-interest does not operate only in this fashion. We must take account of efforts and sacrifices. Here again the language of symbol and diagram is better suited than the popular terminology to express the general idea that all things are in flux, and that the fluxions are inter-dependent. In Professor Marshall's words, "as a rule, the cost of production of a thing is not fixed; the amount produced and its normal value are to be regarded as determined simultaneously under the action of economic laws. It, then, is incorrect to say, as Ricardo did, that cost of production alone determines value; but it is no less incorrect to make utility alone, as others have done, the basis of value." Among those who may have gone astray in the latter sense, who, in their recoil from Scylla, are at least sailing dangerously near Charybdis, may be placed the important Austrian school who have rediscovered and restated the theory of final utility without the aid of mathematical expression. To amplify a figure suggested by one of them, let us figure the hard conditions of industrial life by the austerity of a schoolmaster who, in order to cultivate patience and fortitude in his scholars, should distribute among them certain rewards—it might be toys and sweets—in return for certain amounts of fatigue and pain endured. Thus the cost of procuring a marble might be writing out twenty lines, the cost of a top standing half-an-hour in the stocks. Supposing exchange to be set up among the members of the youthful population, free competition being assumed, there would theoretically arise an equilibrium of trade in which the value of each article would correspond to its final utility. That is, if a top exchanged for ten marbles, it might be expected that each boy would prize the last top about as highly as the last decade of marbles which he thought fit to purchase. So far final utility might be regarded as the regulating principle. But it is equally true that the final disutilities of the exchanged articles will be equal. If a top is worth ten marbles, we are entitled to expect such an adjustment of trade that each and every boy would as soon stand in the stocks half an hour as write out two hundred lines—the cost of ten marbles at twenty lines per marble. To be sure final utility may be conceived as operating by itself without reference to cost of production, as we tacitly assumed in our first paragraphs. Whereas the converse conception of a traffic in discommodities has less place in real life. But it is not worth while weighing the two principles against each other, *in vacuo*, so to speak, and abstracting the real circumstances by which each is differently modified. As these are introduced the balance will oscillate now in favour of one side, now of the other; perhaps leaving it ultimately uncertain whether cost of production or final utility is the more helpful in the explanation of economic phenomena. I cannot be expected here to enumerate all the

CONDITIONS OF ECONOMIC EQUILIBRIUM.

For a complete exposition of the complexities, at which I have thought it necessary to glance, I must refer to the second book of Professor Sidgwick's "Political Economy." It will be evident to his readers that what may be called the general economic problem of several trading bodies distributing and exchanging *inter se* under the influence of self-interest and in a régime of competition is much more hopelessly difficult than the as yet imperfectly solved dynamical problem of several material bodies acting on each other *in vacuo*. When Gossen, the predecessor of Jevons as exponent of the law of final utility, compares that principle to the law of gravitation, and the character of our science to that of astronomy, he betrays a too parental partiality. A truer, though still too flattering, comparison would be afforded by some very immature and imperfect specimens of physics, say the theory of fluid motion applied to the problems of house ventilation. There is a certain resemblance between the uniformity of pressure to which the jostling particles of a gas tend and the unity of price which is apt to result from the play of competition. As the architect is guided by studying the laws according to which air flows, so it will help the builder of economic theory to have mastered the principle of movement towards equilibrium. But even in the material constructions practice is apt to lag far behind theory, as every reader in the British Museum knows. Much less are we able to predict what currents will flow between the different compartments of the industrial system. We know so imperfectly the coefficient of fluid friction and the other conditions of the general problem: what compartments may be regarded as completely isolated and hermetically sealed, which partitions are porous and permeable. Moreover, there is one operation of competition, which it does not seem easy or helpful to represent by physical analogies—the transference from one occupation to another, the equation of net advantages or total utilities in different employments; industrial as distinguished by Cairnes from commercial competition. The latter operation appears to me to admit much better of mathematical expression than the former, which is not so well represented by the equilibrium of a physical system. Accordingly, the equation of net advantages has been judiciously omitted by Jevons in his formulation of the cost of production. And the Helvetian Jevons, as we may call Professor Walras, appears to have altogether made abstraction of the cost of production considered as importing sacrifice and effort. Professor Walras, illustrating the operation of a simple market, supposes each dealer, before going to market, to write down his scale of requirements—how much he would be willing to buy or to sell at each price. From these data it would be easy to calculate beforehand the rate of exchange which would prevail in the market formed by those individuals. But, when we advance from the simplest type of market to the complexities introduced by division of labour, it is seen to be no longer a straightforward problem in algebra or geometry, given the natures of all the parties, to find the terms to which they will come. Here, even if we imagine ourselves in possession of numerical data for the motives acting on each individual, we could hardly conceive it possible to deduce *à priori* the position of equilibrium towards which a system so complicated tends. Accordingly, it may be doubted whether the direct use of mathematical formulæ extends into the region of concrete phenomena much below the height of abstraction to which Jevons has confined himself. However, the formulation of more complicated problems has still a negative use, as teaching the Socratic lesson that no exact science is attainable. In the vineyard of science, to perform the part of a pruning-hook is an honourable function, and a very necessary one in this age of luxuriant speculation, when novel theories teem in so many new economic journals. I give in the appended notes an example of this corrective process applied to a theory of great worth and authority, and concerning the most vital interests, such as the relations of employer and employed, and

THE SOCIALIST ATTACK ON CAPITAL.

In directing this weapon of criticism against Professor Walker, I act upon the Miltonic rule for selecting an adversary—

> Best with the best, more glory will be won,
> Or less be lost.

In the preceding remarks I have had in view, as presumably most favourable to computation, the case of bargains in which there is competition on both sides. It is now to be added that the mathematical method is nearly as applicable to

A REGIME OF MONOPOLY.

Here Cournot, rather than Jevons, is our guide. Cournot's masterly analysis of the dealings between a monopolist seller and a number of buyers competing against each other has been copied out of mathematics into the vulgar tongue by many well-known writers, and need not here be repeated. It is in this department, perhaps, that we can best answer Cairnes's challenge to Jevons to produce any proposition discovered by the mathematical method which is not discoverable by ordinary reasoning. Not, indeed, that the economist is bound to answer that challenge, any more than, in order to prove the advantages of international trade, he is concerned to deny that claret may be produced in Scotland. The following proposition is a particular case of a more general theorem given by Cournot. Let there be a railway and a line of steamers, each forming part of a certain through journey, and separately useless; the fares will be lower when both means of transport belong to a single company than where there is less monopoly, the two services being in the hands of two companies, each seeking its own gain independently of the other. The rationale of this somewhat paradoxical proposition is not easily discerned without the aid of symbols. Cournot, in a popular redaction of the theories which he first conceived in a mathematical form, suggests, as a generally intelligible explanation, that it is better to be at the mercy of a single master than of several petty tyrants. But this seems to be a commonplace of the sort which, in the absence of rigid reasoning, has so often deceived the amateur economist. Might it not be applied to the case of monopoly in general? It would be hard to say how much this remarkable proposition may add to the arguments in favour of the Government monopolising railways. Nor would I undertake to estimate the practical significance of Cournot's numerous mathematical theorems on the taxation of monopolists. We might perhaps compare the function of the sovereign science with respect to the theory of monopolies to the duty of Government as to their management—to exercise a general supervision without attempting to control details. We have in the last few paragraphs been supposing monopoly on one side of the market, on the other side a public competing with each other. Let us now consider the bargain between two monopolists, whether individuals, or rather corporate trading bodies, combinations in the most general sense of the term. The mathematical analysis of this case brings very clearly into view the important property, which is not very prominent in writings of the pre-Jevonian era, that the bargain between two self-interested co-contractors is not determinate in the same sense as in a regime of perfect competition. No doubt, if we take a very simple case—such as that imagined by De Quincey, of a bargain between the owner of a musical-box and a colonist already on his way to a distant region where no luxuries can be purchased—it is easy to see that the bargain may settle down at any point between certain limits. But where both the amount of commodity to be sold and money to be paid are variable, as in the momentous case of a bargain between a combination of employers on the one hand and employes on the other, it is a less familiar truth that the terms of the contract are in general to some extent indeterminate. For instance, the bargain may be either all in the interest of the one party, say long hours and small pay, or on the other hand high wages with much leisure. The significance of this proposition has been missed by many of those who have treated the subject without the aid of the appropriate apparatus. Some fail to see that there is any peculiarity in the bargain between isolated units. Another discerns the indeterminateness of the bargain only in the special case in which the article exchanged is a large indivisible object, like a house. Another limits the difficulty to the case of a single negotiation as distinguished from a contract which, as in the actual labour market, may be modified from time to time. Another tells us that in such a bargain the most anxious party gains least.

A PRINCIPLE OF ADJUSTMENT.

All these phrases seem to obscure the cardinal distinction that perfect competition tends to a determinate settlement, whereas in a régime of combination a principle of adjustment is still to seek. What is that principle? At a former meeting of the British Association, on the occasion of a discussion on sliding scales, I stated the difficulty which there might be, in the absence of competition, in defining fair wages and reasonable terms, and I asked the eminent professor who introduced the subject in what direction one should look for a solution of this difficulty. His reply imported, as I understood, that no other general rule can be given but this: to obtain a full knowledge of, and bring a candid judgment to bear on, all the circumstances relevant to each case. To which I would add that one circumstance relevant to this whole class of cases is just the fact that there is in the abstract such a marked difference between combination and competition. Possibly the dry light of abstract science may enable us to see a little further into this difficulty. Analysis strongly suggests that the right solution is what may be called the utilitarian arrangement, that which is productive of the greatest sum total of advantage for all concerned. This utilitarian determination is clearly discerned to be by no means necessarily coincident with the settlement towards which competition tends. For instance, the "vrai prix," in Condillac's sense, as determined by the play of supply and demand in the labour market, might be such that the entrepreneur class should take the lion's share, leaving the labourer a bare and painful subsistence; but there is no ground to believe that this is the best possible argument. From an abstract point of view it is by no means evident that a free labour market "is the only way to equity, that any interference with it must involve injustice." Nor need it appear "a great fundamental principle—as inevitable in its action as gravitation—that a fair day's wage for a fair day's labour is determined by the proportion which the supply in the market bears to the demand." It may be true indeed, in a practical sense, that perfect competition is "not less harmonious and beneficent in its operation than gravity," but theoretically it is tenable that there is an adjustment of contracts more beneficent than that which the mechanical play of competition tends to establish. To introduce these philosophical conceptions of utilitarianism will doubtless seem irrelevant to those who are immersed in the details of business. But the practical man should be reminded that in other spheres of action, politics and morals, the principle of utility, however badly received at first, has exercised a great influence—though doubtless not so great as was anticipated by some theorists, and requiring to be largely tempered with common sense. Such, I think, are the principal points at which mathematical reasoning is capable of being applied to political economy. In estimating the use of this method it is natural to take as our standard the helpfulness of mathematics in other departments of science. As compared with mathematical physics, the

MATHEMATICAL THEORY OF POLITICAL ECONOMY

shows many deficiencies. First, there is the want of numerical data, which has been already noticed. It is true that there is a faint hope of obtaining what Jevons too confidently expected, statistical data for the relations between supply and price. It is true also that in the higher mathematics conclusions which are quantitative without being numerical are more frequent than is usually supposed. Some political economy is as exact as some mathematical physics. It will not be expected that from such materials any very elaborate piece of reasoning can be constructed. Accordingly another point of contrast with mathematical physics is the brevity of our calculations. The whole difficulty is in the statement of our problems. The purely computative part of the work is inconsiderable. Scarcely has the powerful engine of symbolic language been applied when the train of reasoning comes to a stop. The case is like that of the swell in "Punch," who, about to enter a hansom, enquires solicitously of the driver whether he has got a good horse. "Yes, sir; very good 'oss." "Aw—then dwive to next door." However, our road, though short, is so slippery as to require every precaution. It follows that in Economics, unlike Physics, the use of symbols may perhaps be dispensed with by native intelligence. It must be admitted that the correct theory of value has been rediscovered by Menger, and restated by his follower, Böhm-Bawerk, without the explicit use of mathematics. Without the law, they have done by nature things contained under the law. Still, under a higher dispensation, they might have attained greater perfection. Nor can equal accuracy be ascribed to all the followers of Menger. Nor is the terseness which comes of mathematical study a characteristic of this Austrian school. Another point of contrast between the mathematical science of the physicist and the economist is that the former appeals to a larger public. Mathematics is, as it were, the universal language of the physical sciences. It is for physicists what Latin used to be for scholars; but it is unfortunately Greek to many economists. From these considerations it may appear that our little branch of science is of quite a rudimentary form. The solid structure and regular ramifications of the more developed mathematical sciences are wanting. A less unfavourable contrast would be presented if we compared our method, not with applied mathematics generally, but with that particular branch of it which comes nearest to ours in its proximity to human interests—the use of

THE CALCULUS OF PROBABILITIES IN SOCIAL STATISTICS.

There is really one theorem in the higher part of the calculus, but it is a very difficult one, the theory of errors, or deviation from averages. The direct applications of this theory to human affairs are not very considerable. Perhaps the most conspicuous example is afforded by an investigation to which, if I had undertaken to review the work done in our subjects during the past year, I ought to have directed particular attention—Mr. Galton's rigid proof of the fact and amount of *regression*, or reversion, in children compared with parents, and other relationships. In all these respects there is a considerable resemblance between the higher parts of the two branches of science which are cultivated in this section. It may be said that in pure economics there is only one fundamental theorem, but that is a very difficult one: the theory of Bargain in a wide sense. The direct application of mathematical reasoning is, as we have seen, limited—more limited, I think, than the corresponding function of the higher statistics. But, on the other hand, the regulative effect, the educational influence of studies like those of Cournot and Jevons are probably very extensive. How extensive, it would be difficult to decide without defining the limits of a province within which our special subject is included—the use of abstract reasoning in Political Economy. Now, on this vexed question, and with reference to the heated controversy between the Historical and the Deductive schools, the mathematical economist as such is not committed to any side. It may be dangerous to take wide general views; it may be better to creep from one particular to another rather than ascend to speculative heights. Our only question here is whether, if that ascent is to be made, it is better to proceed by the steep but solid steps of mathematical reasoning, or to beguile the severity of the ascent by the zigzag windings of the flowery path of literature. It is tenable that the former course is safest, as not allowing us to forget at what a dangerous height of abstraction we proceed. As Prof. Foxwell has well said, with reference to the mathematical methods in the hands of Jevons and Professor Marshall:—"It has made it impossible for the educated economist to mistake the limits of theory and practice, or to repeat the confusions which brought the study into discredit and almost arrested its growth." I trust that I have succeeded in distinguishing the question what is the worth of abstract reasoning in Political Economy from the much more easily answered question whether, if it is worth doing, it is worth doing well. The mathematical economist is concerned to separate his method from that mathematical and metaphysical reasoning which Burke repudiates as inapplicable to human affairs; from that abstract method which he has in view when he says:—"Nothing can be more hard than the heart of a thoroughbred metaphysician. It comes nearer to the cold malignity of a wicked spirit than to the frailty and passion of a man." Burke is referring to the Jacobin philosophers; but our withers are unwrung, if similar words should be applied to some of the "sophisters and economists" of a later generation. Just as a political party, if popularly suspected of complicity with crime, would do well to take every opportunity of clearing themselves from that imputation, so the mathematical economist is called on to disown emphatically all sympathy with the flagrant abuses to which the injudicious use of abstract reasoning is undoubtedly liable. We cannot hope to measure the utility of a study with precision, but rather to indicate the estimate on either side of which competent judges would diverge—a central point, which will be found, if I mistake not, equally removed from the position of Gossen, who compares the new science to astronomy, and the attitude of Dr. Ingram towards the researches which he regards as nothing more than "academic playthings, and which involve the very real evil of restoring the metaphysical entities previously discarded." One more general caution is suggested by another of the technical terms which we have employed. What we are concerned to discover is not so much whether mathematical reasoning is useful, but what is its "final utility" as compared with other means of research. It is likely that a certain amount of mathematical discipline—say as much as Mr. Wicksteed imparts in his excellent "Alphabet of Economic Science"—is a more valuable acquisition to a mind already stored with facts than the addition of a little more historical knowledge. But, in reverting to the subject of final utility, I am reminded that presidential addresses, like other things, are subject to this law; and that a discourse on method prolonged beyond the patience of the hearers, is apt to become what Jevons called a discommodity.

Mr. R. H. Inglis Palgrave thanked the president for the admirable address he had given them. He saw in it the foundation of a more careful and definite study of the science to which the president had devoted himself so many years. He (the speaker) had the honour of being one of the presidents of that section at Southampton when Prof. Edgeworth read his first paper to the section. He remembered them being interested in the president's studies, and he was thankful that he had continued them on the method and lines which he expressed in that early paper. He was glad to find that the economic method was again studied in this country, and he thought that the effect of the president's remarks would be to render it impossible for the educated economist to mistake the limits of theory and practice. This would be of the greatest service to their study. (Applause.)

Prof. H. Sidgwick also congratulated Prof. Edgeworth on the performance of that which was certainly a difficult task. (Hear, hear.)

IMPORT DUTIES.

Prof. C. F. Bastable read the first paper on "The Incidence and Effects of Import and Export Duties." In the course of his paper the professor said:—At the outset it is important to remark that the systems of import and export taxes in the various countries of the world should be treated as a whole. We cannot—except provisionally—isolate a single tax, and consider it as quite apart from the general fiscal system. Every tax imposed or abolished is likely to have effects on the course of trade in general, and the state of trade in turn reacts on each particular duty. Conclusions derived from the study of special taxes can never be anything more than probable. The historical development of the system of international taxation shows very clearly the character of the various taxes. The earliest form is that of the transit duty, which sought to gain profit by charging foreigners for the use of the roads or water-ways of a territory. Such taxes appear to be an intermediate form between import and export duties, or perhaps may be better regarded as a combination of both. They possessed the happy feature of bringing in revenue without any loss to the State or obstruction to its domestic industry. They have now, in the new position of European society, ceased to possess any practical interest, unless, indeed, the rates of international railways and inter-oceanic canals can be looked on as similar. Next in order of time is probably the export duty or toll levied on some staple commodity when sold to foreigners. Its primary object was revenue; but it is possible that even in their origin these duties were sometimes intended to benefit a favoured class, by hindering the export of an article which its members consumed. Latest in time, but now by far the most prominent, is the import duty, divided into revenue and protective, according as the competition of home producers who are free from the tax is absent or present. The incidence of an import duty depends on a number of conditions, which it is in practice very hard to estimate with any precision, but which can be indicated generally. They are (1), the conditions of demand: the imposition of a duty on an imported commodity will at first tend to raise its price, and the increased price will probably reduce demand for the commodity within the taxing nation; but the nature of the want satisfied may not allow of such a course. The consumers may take as much, or nearly as much, at the higher price as they did before, when it is plain that the bulk of the tax falls on them. In general, however, demand will be reduced, and it might, therefore, be contended that in such instances the whole tax would not fall on the consumer. This introduces a further element—(2), the extent of demand outside the taxing nation. Foreign producers will not submit to the fall of price that reduced demand will probably cause, so far as they are concerned, if there is any mode of escape, and this refuge they may have in their own and other nations' markets. So that, in addition to the consideration of the intensity of the demand in the taxing country, we have to see what proportion it bears to the total demand. To maintain that an import duty in the Channel Islands would have the same effect as one in the United States is obviously incorrect. Should the taxing country be the sole area of consumption, and should its demand be one easily checked by higher price, it would be in a specially favourable position for levying an import duty. The existence of untaxed substitutes for the commodity also tends to check demand; but in practice this case would not be likely to occur, since it could be avoided by the imposition of equivalent duties on the competing articles. Next, a revenue import tax differs from a protective one, in that the latter, by leaving the native sources of supply untaxed, will help to limit the rise in price of the imported article, acting in the same manner as the existence of an untaxed substitute, but to the loss of the revenue to be derived from the tax so far as the consumption of the imported part of the commodity is reduced. Combining the foregoing elements, we arrive at the conclusion that import duties are not easily shifted *in toto* to the foreign producer, since, to accomplish this result, demand must be feeble, and the taxing country must have a "consumer's monopoly." But though this complete removal of the burden is not to be hoped for, yet, where a large proportion of the demand can be affected, some of the tax will be thrown on the producing country, and in almost every case it is likely that some special classes of producers will be touched by duties imposed at their best market.

Given, however, the conclusion that import duties tend to fall partly on the producing countries, the question remains, what classes will endure the loss? If the industry be in its normal state, capital can only obtain ordinary interest, consequently the operation of the duty will tend to reduce the capital invested in producing the taxed commodity, since other employments will plainly be more advantageous. It is theoretically conceivable that the rate of interest in general would be lowered—the capital when turned to other industries having a lower "final utility." Similar reasoning would apply to ordinary wages and to normal "wages of superintendence," but skilled labour would probably suffer, and so would the "employer's gain" where it exceeds wages of superintendence and conforms to the law of rent. Where raw materials and food are subjected to duties which tend, by limiting demand, to lower price, the margin of production will be raised and rent will fall. A further mode of loss to the producing country may possibly exist, though its amount must in any actual case be very small. The effect of import duties may, as Mill has argued, be to cause a re-distribution of the money-material, thus altering the scale of prices to the advantage of the country which levies the duty. Here the community suffer as consumers of the produce exported from the taxing country, and it may be remarked in passing that the modern organisation of credit enables this effect to be produced without any, or with a very small, transfer of bullion. Where import duties really lower price they have a still further effect in allowing consumers in other countries to get the particular commodity at a reduced rate. It is equally true that the consumer in the producing country gains by the lowered price, an advantage which may set off the possible loss through a lowered scale of prices, and where the commodity is auxiliary to other forms of production would act as a bounty to the industries so using it. Reasoning from general principles, supported by a large mass of evidence, quite suffices to establish the conclusion that the trade of the world is seriously hampered by the action of these taxes. When it is urged that a nation may gain to its neighbours' loss by a series of dexterously arranged import and export dues, those who have no faith in such a policy are perhaps wise in taking the contention on its own ground, and showing what a dangerous implement such a method of taxation is; how impossible it is to foresee the direct, much more the indirect, effects of the measures adopted; but behind and above all minor pleas of the kind lies the claim that national, as well as universal, interest is best promoted by freedom. Against this argument there is, so far as I can see, but one valid objection. The Governments of the world need money, and they can in no way obtain it so easily as by charging tolls on goods that enter their territories, with compensatory excise duties on those goods when produced at home. Such a course brings in revenue without causing the discontent that direct taxation must necessarily produce, and it cannot, therefore, be lightly abandoned. This plea is undoubtedly of weight, the revenue import duty is in this respect clearly marked off from the protective one by being directed solely to the attaining of funds for the State, and, in general, too, by aiming at getting those funds from the consumer. An export duty in the form of an excise, with no drawback, might, too, under the condition of the country having a "producers' monopoly," be defended on the same grounds; but there is another part of the question which has to be considered, viz., the general effect on trade by (1) its limitation, and (2) its diversion through the action of duties. The history of the reforms of English fiscal policy during the present century affords admirable illustrations. On the first point abundant evidence has been collected by Mr. Porter as to the effect of low duties in causing, or rather in not retarding, the expansion of trade and consumption; to which we have only to add that 'no duty' is the lowest one possible, and causes no interference whatever with the natural progress of trade. The second is equally true. It is impossible to so arrange duties that they shall not more or less disturb the proportionate value of the taxed articles; but every disturbance of values alters the force of demand, so that ill-adjusted revenue duties have this fault in common with protective taxes, that they in many cases lead the consumers to buy a less suitable article, or to abstain from that particular enjoyment; in each case, too, depriving the State of revenue, in addition to the privation suffered by the individual.

The British Empire affords some striking cases of tariff absurdities. Take, *e.g.*, the West Indian Islands: there are at least thirteen distinct customs areas, levying variously-graded import and export duties. West Indian planters complain bitterly of continental sugar bounties, but say little of the export duties levied on that article in ten of the islands. Surely a fiscal union of the islands and a revised tariff would be an obvious boon. An Australasian customs union is a practical matter for colonial statesmen, and it could scarcely be anything but advantageous. Still more ambitious schemes have been proposed for the union of even larger "nations," or groups of nations, using the latter term in its economic meaning. Such are the proposals to form a Zollverein of the British Empire, or of the North American Continent; or, again, the plan of De Molinari and Kaufmann for a customs league between France and Germany leading to a league of Central Europe.

Mr. STEPHEN BOURNE opened the discussion on the paper. He said one danger in treating the matter before them, from a mathematical point of view, was because it ignored all the mutiplicity of differences in the positions of parties on whom the taxes fell, and these were really the truth of the matter, and not mere incidence. An import duty was an evil, because it enhanced the cost to the consumer. Then came the consideration as to the best mode in which a country could raise money for its exigencies. He thought that the imposition of import duties was by far the easiest and most economical mode which a country could have for obtaining the necessary funds for its expenditure. Therefore, while they desired, in the interests of the consumer and of trade, generally speaking, the abrogation of all import duties as an economic and necessary measure, it was exceedingly wise that we should continue them. As an ardent free trader, he thought our legislation, with regard to imports, was carried to too great an extent, and that Peel, when he removed imposts from so many articles, went to the extreme. Because if money was to be raised it was often most convenient to do it by imposts on imports. A proper subject for import duty was an article which could not be produced in the country—an article on which the tax was economically laid, an article which was somewhat too bulky to facilitate illicit importation. In all these respects he took it that tea was a typical article. A tax on tea would fall on every member of the community. If it were necessary to raise money for the benefit of the people it was right that every individual who got the benefit of the expenditure of that money should bear his share of the tax. As to export duties, if they were levied for the purpose of restricting the export of any article with the object of getting the price cheapened in the country which levied those duties, there it seemed to him an objectionable interference with freedom of trade.

Mr. R. H. I. PALGRAVE compared present taxation with that of fifty years ago. At that period 868 articles paid import duties. 176 produced 95 per cent., or £21,000,000; 29 produced 4 per cent., or nearly £1,000,000; 144 produced 1 per cent., or £363,000; 531 produced £80,000; and there was a loss on 147. So, fifty years ago we raised £50,000,000 by import duties. Now, in 1888, the picture was entirely changed. Three articles produced at the present time 90 per cent. of our import duties, or £18,000,000; three articles—which included coffee—produced 9 per cent., or £1,800,000; 47 articles produced 1 per cent., or about £200,000. Altogether about £20,000,000. They might thus see, when they saw how very few articles really paid high import duties in this country, that our trade for this purpose was practically free. (Hear, hear.)

Mr. J. B. MARTIN congratulated Prof. Bastable for having shown the gradual extension of freedom of trade which had taken place in this and other countries.

Sir GEO. BADEN-POWELL, M.P., said the taxes must be taken together if they wished to see how the incidence affected the nation. If England entered into Zollverein with her colonies, an obstruction would be set up to the foreign trade of the latter. He hoped the lesson they would learn from the paper would be to stand by the great principle that taxation, whether direct or indirect, should interfere as little as possible with the freedom of production and exchange.

Mr. T. H. ELLIOTT was opposed to any uniformity of taxation on account of the varying strength of demand.

The section then adjourned for luncheon.

Upon reassembling,

Prof. SIDGWICK resumed the discussion. He agreed that revenue duties imposed for protection might to some extent place a country in a very unique position of having more money than it wanted to spend, as had been the experience of the United States. At the same time he agreed that we could not dispense with disturbance with the natural order of production and consumption; and if we adopted what seemed to him, as to Mill, the sound principle of equitable distribution of taxation—the apportionment of taxation of superfluous income—we must practically collect the share of the poor by taxation of cheap luxuries.

The Rev. W. CUNNINGHAM having spoken,

Mr. G. W. HASTINGS, M.P., said, on the bare fiscal question whether we ought to raise duty on an article, he would say, perfectly harmless and admitted to be used by the bulk of people, such as tea, it seemed to him the question must necessarily be dealt with in a twofold aspect. There was an abstract aspect as to whether it was advisable, in the interests of the people, to levy a duty, and therefore probably raise the price of any article that was useful or inocuous to the people. It might be fairly urged that such a duty would check importation, consequently check trade, and diminish our power of exchange with other countries. All that was perfectly true. But then there was another aspect which commended itself to his mind. The province of the strict economist was one thing, but the province of any one who was charged, in however humble a degree, with providing for the fiscal necessities of the people through the House of Commons, was another. This necessitated looking at the question from another point of view. He ventured to point out that the present condition of this country, in its totality of relations, foreign and colonial, as well as domestic, necessitated the raising of a certain amount of revenue—something like ninety millions during every year. And he wanted to know how any one who was compelled to look at questions such as these in the light of legislation, or rather of administration of the national finances, through the great finance committee—the House of Commons—how it was possible for him to disregard the fact that the revenue must be raised, and if not in some degree raised by indirect taxation of imports, it must come out of direct taxation, which would fall almost, if not all together exclusively upon certain classes of the community to the exclusion of others. The burden already thrown on those portions of the inhabitants of the country, who, if not the most powerful, were far the most educated and most capable of making their wants and wishes known, was already very heavy. Every change in financial legislation tended to make it still more severe. And he confessed, if it were determined to abandon all import duties—which, no doubt, would be the logical result of adopting the principles of the paper which had been read, so far as Parliament were concerned—he should expect only one result would follow :—Either there would be an inadvisable reduction in national expenditure—expenditure on necessary objects—or there would be such an amount of discontent and even suffering entailed on certain classes of the community as to probably imperil the even course of our administration.

Mr. MACKNIGHT was of opinion that free trade was the only principle of justice to every class, if we wished to advance in progress. Imposts should be reduced as much as possible, but if a duty could be put on an article without raising its price it ought to be put on. (Laughter.)

Prof. BASTABLE briefly replied on the discussion.

Mr. STEPHEN BOURNE submitted a paper on "Index-numbers as applied to the Statistics of Imports and Exports."

SECTION G.—MECHANICAL SCIENCE.

President.—William Anderson, M.Inst.C.E.

Vice-Presidents.—The Right Hon. Lord Armstrong, C.B., LD.D., D.C.L., F.R.S. ; Sir Frederick J. Bramwell, Bart., D.C.L., F.R.S., M.Inst.C.E. ; Sir Benjamin Chapman Browne ; Principal Garnett, M.A., D.C.L. ; Professor Alex. B. W. Kennedy, F.R.S., M.Inst.C.E. ; Percy Westmacott, M.Inst.C.E.

Secretaries.—C. W. Cooke ; W. Bayley Marshall, M.Inst.C.E. ; Hon. C. A. Parsons, B.A. ; E. Rigg, M.A. (Recorder).

Place of meeting, the Presbyterian Church, Barras Bridge.

ADDRESS BY MR. WM. ANDERSON.

Mr. Wm. Anderson, M.I.C.E., in his address to this section said :—Five years ago, at Montreal, in his address to the Mathematical Section, Sir William Thomson took for his subject the ultimate constitution of matter, and discussed, in a most suggestive manner, the very structure of the ultimate atoms or molecules. He passed in review the theories extant on the subject, and pointed out the progress which had been made in recent years by the labours of Clausius, of Clerk Maxwell, of Tait, and of others, among whom his own name, I may add, stands in unrivalled prominence. I will not presume to enter into the field of scientific thought and speculation traversed by Sir William Thomson, because I am only too conscious that both my mathematical knowledge and my acquaintance with the natural sciences is too limited to entitle the views which I may have formed to any respect ; I propose to draw attention only to some general considerations, and to point out to what extent they practically interest the members of this section.

MENDELEEFF'S EQUILIBRIUM THEORY.

In a lecture delivered at the Royal Institution last May, Professor Mendeleeff attempted to show that there existed an analogy between the constitution of the stellar universe and that of matter as we know it on the surface of the earth, and that from the motions of the heavenly bodies down to minutest interatomic movements in chemical reactions the third law of Newton held good, and that the application of that law afforded a means of explaining those chemical substitutions and isomerisms which are so characteristic, especially of organic chemistry. Examined from a sufficient distance, the planetary system would appear as a concrete whole, endowed with invisible internal motions, travelling to a distant goal. Taken in detail, each member of the system may be involved in movements connected with its satellites, and again each planet and satellite is instinct with motions which, there is good reason to believe, extend to the ultimate atoms, and may even exist, as Sir W. Thomson has suggested, in the atoms themselves. The total result is complete equilibrium, and, in many cases, a seeming absence of all motion, which is, in reality, the consequence of dynamic equilibrium, and not the repose of immobility or inertness.

THE THREE STATES OF MATTER.

The movements of the members of the stellar universe are, many of them, visible to the eye, and their existence needs no demonstration ; but the extension of the generalisation just mentioned to substances lying, to all appearances, inert on the earth's surface is not so apparent. In the case of gases, indeed, it is almost self-evident that they are composed of particles so minute as to be invisible, in a condition of great individual freedom. The rapid penetration of odours to great distances, the ready absorption of vapour and of other gases, and the phenomena connected with diffusion, compression, and expansion seem to demonstrate this. One gas will rapidly penetrate another and blend evenly with it, even if the specific gravities be very different. The particles of gases are, as compared with their own diameters, separated widely from each other; there is plenty of room for additional particles ; hence any gas which would, by virtue of its molecular motion, soon diffuse itself uniformly through a vacuum will also diffuse itself through one or more other gases, and once so diffused, it will never separate again. A notable example of this is the permanence of the constitution of the atmosphere, which is a mere mixture of gases. The oxygen and the nitrogen, as determined by the examination of samples collected all over the world, maintain sensibly the same relative proportions, and even the carbonic acid, though liable to slight local accumulations, preserves, on the whole, a constant ratio, and yet the densities of these gases differ very greatly. Liquids, though to a much less degree than gases, are also composed of particles separated to a considerable relative distance from each other, and capable of unlimited motion where no opposing force, such as gravity, interferes : for under such circumstances their energy of motion is not sufficient to overcome the downward attractions of the earth ; hence they are constrained to maintain a level surface. Liquids, therefore, are porous bodies whose constituent particles have great freedom of motion. It is no wonder, consequently, that two dissimilar liquids, placed in contact with each other, should interpenetrate one another completely, if time enough be allowed; and this time, as might be expected, is considerably greater than that required for the blending of gases, because of the vastly greater mobility of the particles of the latter. The diffusion of liquids takes placee not only when they are in actual contact, but even when they are separated by partitions of a porous nature, such as plaster of Paris, unglazed eartnenware, vegetable or animal membranes, and colloidal substances, all of which may be perfectly water-tight, in the ordinary sense of the term, but yet powerless to prevent the particles of liquids making their way through simultaneously in both directions.

When we come to solid substances the same phenomena appears. The volumes of solids do not differ greatly from the volumes of the liquids from which they are congealed, and the solid volumes are generally greater. The volume of ice, for example, is one-tenth greater than that of the water from which it separates. Solid cast-iron just floats on liquid iron, and most metals behave in the same way; consequently, if the liquids be porous the solids formed from them must be so also; hence, as might be expected, solids also occlude gases in a remarkable manner. Not only are gases occluded, but they are also transpired under favourable conditions of temperature and pressure, and even liquids can make their way through. Red-hot iron tubes will permit the passage of gases through their substance with great readiness. Mr. Goodman stated, during a recent discussion at the Institution of Civil Engineers, that petroleum passed through a red-hot boiler plate half an inch thick, and it is well known that mercury will penetrate tin and other metals with great rapidity, completely altering their structure, their properties, and even their chemical compositions. The evidence of the mobility of the atoms or molecules of solid bodies is overwhelming.

HEAT AND MOLECULAR ENERGY.

At high temperatures the effects are more easily produced on account of the greater energy of motion of the atoms or molecules. In the process of the manufacture of steel by cementation, or in case-hardening, the mere contact of iron with solid substances rich in carbon is sufficient to permit the latter to work its way into the heart of the former, while in the formation of malleable cast-iron the carbon makes it way out of the castings with equal facility, it is a complete case of diffusion of solid substances through each other, but, on account of the inferior and restricted mobility of the particles at ordinary temperatures, a higher degree and longer time are needed than with liquids or gases. Again, when, by the agency of heat, molecular motion is raised to a pitch at which incipient fluidity is obtained, the particles of two pieces will unite into a homogeneous whole, and we can thus grasp the full meaning of the operation known as 'welding.' By the ordinary coarse methods but few substances unite in this way, because the nature of the operation prevents, or at any rate hinders, the actual contact of the two substances; but when molecular motion is excited to the proper degree by a current of electricity, the faces to be joined can be brought into actual contact, the presence of foreign substances can be excluded, and many metals not hitherto considered weldable, such as tool steel, copper, and aluminium, are readily welded.

EFFECT OF LIGHT AND ELECTRICITY.

Energy in the form of light operates changes in the surface of bodies, causing colours to fade, and giving to photography the marvellous power which it posesses; decomposing the carbonic acid of the atmosphere in the chlorophyl of green leaves, and determining chemical combinations, such as chlorine with hydrogen to form hydrochloric acid, or carbonic oxide with clorine to form chlorocarbonic acid. It is inconceivable that these effects could be produced unless the undulations of light were competent to modify the molecular motions already existing in the solid liquid and gaseous bodies affected Electricity exerts a similar influence. Generated by the molecular movements caused by chemical activity, whether directly, as in the primary battery, or indirectly as in the dynamo, it is competent to increase the molecular movements in bodies so as to produce the effects of heat directly applied; it is capable of setting up motions of such intensity as to produce chemical changes and decompositions, to say nothing of the whole series of phenomena connected with magnetism, with induction, or the action through space and through non-conducting bodies, which, as in the case of radiant heat and light, seems to imply the existence of an interatomic ether. Conversely, changes of molecular equilibrium, brought about by the action of external forces, produce corresponding changes in electrical currents: witness the effects of heat, for example, on conductivity and the wondrous revelations of molecular change obtained by the aid of Professor Hughes's induction balance. The behaviour of explosives illustrates also, and in a striking manner, the effects of disturbing molecular equilibrium. An explosive is a substance which contains in itself, in a solid or liquid form, all the elements necessary to produce a chemical change by which it is converted into the gaseous state. The application of heat, of pressure, or of impact, causes, as in Professor Spring's experiments, chemical union to take place, first at the spot where the equilibrium is disturbed by the application of external force, and afterwards, with great rapidity, through the mass, the disturbance being propagated either by the air surrounding the particles or by the luminiferous ether, with all the rapidity of light; the chemical reaction is accelerated by the pressure which may arise, for example, if the explosive be confined in the chamber of a gun or in the bore-hole of a blast. High explosives, as they are termed, are comparatively inert to ordinary ignition; but when the molecular equilibrium is suddenly disarranged throughout the mass by the detonation of a percussion fuse, combination takes place instantly throughout, and violent explosion follows. In a similar manner some gases, such as acetylene, cyanogen, and others, can be decomposed by detonation and reduced to their solid constituents. Professor Thorpe has devised a very beautiful lecture experiment, in which carbon disulphide is caused to fall asunder into carbon and sulphur by the detonation of fulminate of mercury fired by an electric spark. In these cases a reverse action takes place, but illustrates equally well the conversion of one form of energy into others, and the consequent disturbance of molecular equilibrium in the substances affected. It seems to me clear, therefore, that the time has come when the conception of dynamic equilibrium in the ultimate particles of matter in all its forms must take the place of the structural system of inert particles.

AN APT ILLUSTRATION.

I cannot conceive how the phenomena which I have enumerated can be explained on the supposition that matter is built up of motionless particles—how, for example, a stack of red and yellow bricks could ever change the order of arrangement without being completely pulled asunder and built up again, in which case an intermediate state of chaos would exist; but I can easily comprehend how a dense crowd of people may appear as a compact mass, streaming, it may be, in a definite direction, and yet how each member of that mass is endowed with limited motion, by virtue of which he may push his way through without disturbing the general appearance; how the junction of two crowds would form one whole, though, perchance, altered in character; and how even Professor Spring's experiments may be explained by the supposition that bystanders on the edge of a crowd would be forced, by external pressure, to form part of it and partake of its general movements.

THE HARDENING OF STEEL.

When it is conceded that molecular motion pervades matter in all its forms, and that the solid passes, often insensibly, into the fluid, or even direct into the gaseous, it follows, almost of necessity, that there must be a borderland, the limits of which are determined by temperature and pressure, in which substances are constantly changing from one state to another. This is observable in fusion, but to a marked degree in evaporation, where the particles are being incessantly launched into space as gas and return as constantly to the liquid state. If steel be looked upon as a solution of carbon and iron, then the hardening of steel is explained by the theory that dissociation has taken place at the temperature at which it is suddenly cooled, the sudden cooling fixing the molecular motion at such an amplitude or phase that it gives a characteristic structure, one of the properties of which is extreme hardness. In tempering, the gradual communication of heat causes dissociation again to take place, the molecular equilibrium is modified by the increased energy imparted to the particles, and when suddenly cooled at any point there remains again a distinct substance, composed of iron and carbon, partly in various degrees of solution and partly free, and again possessing special mechanical qualities. That steel, and probably other alloys, differ in the nature of their composition according to the way in which they are worked, both with respect to heat and mechanical pressure, has been abundantly proved by many eminent metallurgists, and especially by Sir Frederick Abel, in the extended researches which he has recently carried out, on the hardening of steel, for the Institution of Mechanical Engineers, and it would appear as a natural sequence that the properties of steel would be greatly affected by the manner in which its temperature was changed, as we indeed find that it is when these changes are produced by baths of melted metals, by oil, or by water at different temperatures. The action which takes place may be illustrated by what would happen supposing that a complicated dance, such as the Lancers, were suddenly stopped in various phases of the figures. The component parts would always remain the same, but the relative distribution of the partners would vary continually, and analysis would show that at one time each gentleman was associated with a particular lady; at another, that two ladies were attached to a single gentleman, while a number of gentlemen had no partners at all; and yet, again, at another, that the movements which were once rectilinear have become circular. In each case the groups would assume a totally distinct appearance.

INFLUENCE OF SMALL CHANGES.

It may be urged, however, that it is unlikely that alloys or solutions could be affected in a manner so marked merely by small changes at comparatively low temperatures; but I would observe that "great and little" are relative terms, and we have abundant evidence of the immense effects produced by what would be called "little" causes. Sir Frederick Bramwell, in his address last year, drew attention to the importance of the "next to nothing." It is not so very long ago that any one would have been considered a dreamer for propounding a theory that the presence of the fraction of a per cent. of carbon, phosphorus, or sulphur would totally alter the character of iron; that the addition of one two-thousandth part of aluminium or molten iron would make the pasty mass as fluid as water; that the presence of the smallest impurity in copper would have a disastrous effect on its powers of conducting electricity; and that the addition of one thousandth part of antimony would convert the "best selected" copper into the worst conceivable. I need hardly allude to the great part played in nature by microscopic organisms, and how much of the beauty of our seas and rivers is derived from substances so minute that nothing but the electric beam of Professor Tyndall is capable of revealing their presence.

THE PERIODIC LAW.

There is one more circumstance connected with my subject to which I must draw your attention, because, though its application to the mechanical properties of substances is very recent, it promises to be of great importance. I allude to the Periodic Law of Dr. Mendeleef. According to that law, the elements, arranged in order of their atomic weights, exhibit an evident periodicity of properties, and, as Professor Carnelley has observed, the properties of the compounds of the elements are a periodic function of the atomic weights of their constituent elements. Acting on these views, Professor Roberts Austin has recently devoted much time and labour to testing their exactness with reference to the mechanical properties of metals. The investigation is surrounded by extraordinary difficulties, because one of the essential features of the inquiry is that the metals operated on should be absolutely pure. For chemical researches, a few grains of a substance are all that is needed, and the requisite purity can be obtained at a moderate cost of time and labour; but when mechanical properties have to be determined considerable masses are needed, and the funds necessary for obtaining these are beyond the reach of most private individuals. In view of the difficulty of obtaining metals of sufficient purity, he selected gold as his base, because that metal can be more readily brought to a state of purity than any other, and is not liable to oxidation. In a communication to the Royal Society made last year he shows that the metals alloyed with gold which diminish its tenacity and extensibility have high atomic volumes, while those which increase these properties have either the same atomic volumes as gold or have lower ones. The inquiry has only just been commenced, but it appears to me to promise results which, to the engineer, will prove as important and as fruitful of progress as the great generalisation of Mendeleeff has been to chemists. A law which can not only indicate the existence of unknown elements but which can also define their properties before they are discovered, if capable of application to metallurgy, must surely yield most valuable results, and will make the compounding of alloys a scientific process instead of the lawless and haphazard operation which it is now.

EFFECTS OF EXTERNAL FORCES.

Every one will admit that an external force cannot be applied to a system in motion without affecting that motion; consequently matter, in whatever state, cannot be touched without changes taking place which will be more or less permanent. The application of heat will cause a change of volume, and, at last, a change of condition; the application of external stresses will also produce a change of volume; and it is natural to infer that there must be some relation between the two, and, accordingly, Professor Carnelley has drawn attention to the fact that the most tenacious metals have high melting-points, though here again there is a great want of exactness, partly on account of the difficulty of measuring high temperatures, and partly by reason of the scarcity of pure materials. Again, long-continued stresses, or stresses frequently applied, may be expected to produce permanent changes of form, and so we arrive at what is termed the fatigue of substances. Stretched beyond their elastic limits, which limits I do not suppose to exist except when stresses are applied quickly, substances are permanently deformed, and the same effects follow the long application of heat. The constant recurrence of stresses, even those within the elastic limit, causes changes in the arrangement of the particles of substances which slowly alter the properties of the latter, and in this way pieces of machinery, which theoretically were abundantly strong for the work they had to perform, have failed after a more or less extended period of use. The effect is intensified if the stresses are applied suddenly, if they reach nearly to the elastic limit, and if they are imposed in two or more directions at once, for then the molecular disturbance becomes very intense, the internal equilibrium is upset, and a tendency to rupture follows. Such cases occur in artillery, in armour-plates, in the parts of machinery subject to impact; and, as might be expected, the destructive effects do not always appear at once, but often after long periods of time. When considerable masses of metal have to be manipulated by forging, or by pressure in a heated condition, the subsequent cooling of the mass imposes restrictions on the free movement of some, if not all, of the particles; internal stresses are developed which slowly assert themselves, and often cause unexpected failures. In the manufacture of dies for coining purposes, of chilled rollers, of shot and shell hardened in an unequal manner, spontaneous fractures take place without any apparent cause, and often after long delay, the reason being that the constrained molecular motion of the inner particles gradually extends the motion of the outer ones until a solution of continuity is caused. Similar stresses occur in such masses as crank shafts, screw shafts, gun hoops, &c. The late General Kalakoutsky some seventeen years ago commenced a systematic investigation into the internal stresses in the tubes and hoops of guns and in armour-piercing shells. The method he pursued was to cut discs or rings about half an inch thick off the hoops and shells to divide the metal of each disc into from four to six rings, to fix by means of silver plugs, on which very finely marked cross-lines were drawn, from four to eight points on the surface of each ring, and then to measure, with extreme exactness, the changes in diameter produced in every ring by the successive cutting of the rings. Knowing by direct tests the mechanical properties of his material, he was able, from the changes in the diameters, to calculate what the tangential stresses in every part of each disc were, and to draw inferences as to their fitness for the work they were intended to perform. The same method of investigation has been pursued by Captain Noble of the Elswick Works, and by Lieutenant Crozier of the United States Artillery, with the practical result that probably much more attention will be paid in future to the principles on which the annealing and hardening of steel is carried on. A gun hoop or tube, to be in the best condition to resist a bursting stress, should have its inner surface in a state of compression and its outer in a state of tension, and the hoops should be shrunk on to the tubes or on to each other with but very little pressure. General Kalakoutsky proposed, in order to set up beneficial internal stresses, that tubes which were being annealed should be cooled from the inside by a jet of steam, of air, of water, or of oil; and he advocated the practice of testing the effects of each new method of manufacture or of treatment by the careful measurements of slices of the finished material instead of working at random, as is still very much the practice. It is evident, also, that a sample of steel cut out of a gun hoop or crank shaft, and tested, can afford no indication of the available tenacity of the same sample *in situ*. When released from the constraint of its surroundings, the particles must, of necessity, change their condition, for the disturbing forces have been removed; and the probability is that, if the steel be good, the test will prove satisfactory, especially if some time be allowed to elapse between cutting out the sample and testing it, and a false security will be engendered such as has often led to disastrous results.

INFLUENCE OF TIME.

The influence of time on steel seems to be well established; the highest qualities of tool steel are kept in stock for a considerable period; and it seems certain that bayonets, swords, and guns are liable to changes which may account for some of the unsatisfactory results which have manifested themselves at tests repeated after a considerable interval of time. As all these things have been hardened and tempered, there must necessarily have been considerable constraint put upon the freedom of motion of the particles. This constraint has gradually been overcome, but at the expense of the particular quality of the steel which it was originally intended to secure. I have now laid before you the views respecting the constitution of matter which I think are gaining ground, which explain many phenomena with which we are familiar, and which will serve as guides in our treatment of metals, and especially of alloys; but I must admit that the subject is still by no means clear, that a great deal more definition is wanted, and that we are still awaiting the advent of the man who shall do for molecular physics what Newton did for astronomy in explaining the structure of the universe.

PETROLEUM.

One of the most remarkable features of the last thirty years is the introduction of petroleum, and the wonderful development to which the trade in it has attained. Under the generic name of petroleum are embraced a variety of combinations of carbon and hydrogen, each of which is distinguished by some special property. At ordinary temperatures and pressures some are gaseous, some are liquid, and some solid, and most are capable of being modified by suitable treatment under various temperatures and pressures. The employment of petroleum in the arts is still extending rapidly. Used originally for illuminating purposes, it is now employed as fuel for heating furnaces and steam-boilers; as a working agent in heat engines, valuable medicinal properties have been discovered; and as a lubricant it stands unrivalled. As an illuminant, even in this country, it is, to a large extent, superseding every other in private houses, and even in public lamps, because it gives a cheaper and more brilliant light than ordinary gas, and leaves the consumer free from the tyranny of great and privileged companies. As fuel it is especially convenient, cleanly, and economical. Stored in tanks of suitable construction, it is sprayed into the furnace without labour and without creating dust and dirt; and it is especially convenient in locomotive and marine work on account of the rapidity, ease, and cleanliness with which it can be run into the tender or into the oil-bunkers of a ship. As a working agent in heat engines it is employed in two ways. First as a vapour, generated from the liquid petroleum contained in a boiler, very much in the same way as the vapour of water is used in an engine with surface condenser, the fuel for producing the vapour being also petroleum. Very signal success has been obtained by Mr. Yarrow and others in this mode of using mineral oil, especially for marine purposes and for engines of small power; there seems to be no doubt that by using a highly volatile spirit in the boiler a given amount of fuel will produce double the power obtainable by other means, and at the same time the machinery will be lighter and will occupy less space than if steam were the agent used. The other method is to inject a very fine spray of hot oil, associated with the proper quantity of air, into the cylinder of an ordinary gas-engine, and ignite it there by means of an electric spark or other suitable means. Attempts to use oil in this way date back many years, but it was not till 1888 that Messrs. Priestman Brothers exhibited at the Nottingham show of the Royal Agricultural Society an engine which worked successfully with oil, the flashing point of which was higher than 75° F., and was therefore within the category of safe oils. The engine exhibited was very like an ordinary Otto gas-engine, and worked in exactly the same cycle. A pump at the side of the engine forced air into a small receiver at a few pounds' pressure to the square inch. The compressed air, acting by means of a small injector, carried with it the oil in the form of fine spray, which issued into a jacketed chamber heated by the exhaust, in which the oil was vapourised. The mingled air and oil was thus raised to a temperature of about 300 deg., and was then drawn, with more air, into the cylinder, where, after being compressed by the return stroke of the piston, it was exploded by an electric spark, and at the end of the cycle the products of combustion were discharged into the air after encircling the spray chamber and parting with most of their heat to the injected oil. The results of careful experiments made by Sir William Thomson and myself on different occasions were, that 1·73 lb. of petroleum were consumed per brake-horse power per hour; but the combustion was by no means perfect, for a sheet of paper held over the exhaust pipe was soon thickly spattered with spots of oil.

PETROLEUM FOR FURNACE PURPOSES.

It is hardly necessary to state that the use of petroleum for furnace purposes of all kinds is increasing very rapidly, and the demand has naturally re-acted on the supply in promoting improved means of transport; and Newcastle again has led the van in this matter, for Sir William Armstrong, Mitchell, and Co. have sent a out fleet of steamers constructed to carry the oil in bulk with perfect safety, both as regards the stowage of a cargo so eminintly shifting, and with respect to risk from fire and from explosion.

ORIGIN AND PROSPECTS OF THE SUPPLY.

The enormous consumption of petroleum and of natural gases frequently raises the question as to the probability of the proximate exhaustion of the supply: and, without doubt, many fear to adopt the use of oil, from a feeling that if such use once becomes general the demand will exceed the production, the price will rise indefinitely, and old methods of illumination, and old forms of fuel, will have to be reverted to. From this point of view it is most interesting to inquire what are the probabilities of a continuous supply; and such an investigation leads at once to the question, "What is the origin of petroleum?" In the year 1877 Professor Mendeleeff undertook to answer this question; and as his theory appears to be very little known, and has never been fully set forth in the English language, I trust you will forgive me for laying a matter so interesting before you. Dr. Mendeleeff commences his essay by the statement that some persons assume, without any special reason—excepting, perhaps, its chemical composition—that naphtha, like coal, has a vegetable origin. He combats this hypothesis, and points out, in the first place, that naphtha must have been formed in the depths of the earth. It could not have been produced on the surface, because it would have evaporated; nor over a sea bottom, because it would have floated up and been dissipated by the same means. In the next place he shows that naphtha must have been formed beneath the very site on which it is found—that it cannot have come from a distance, like so many other geological deposits, and for the reasons given above, namely, that it could not be water-bourne, and could not have flowed along the surface, while in the superficial sands in which it is generally found no one has ever discovered the presence of organised matter in sufficiently large masses to have served as a source for the enormous quantity of oil and gas yielded in some districts; and hence it is most probable that it has risen from much greater depths under the influence of its own gaseous pressure, or floated up upon the surface of water, with which it is so frequently associated. One of the first indices to the solution of the question lies in the situation of the oil-bearing regions. They always occur in the neighbourhood of, and run parallel to, mountain ranges—as, for example, in Pennsylvania, along the Alleghanies; in Russia, along the Caucasus. The crests of the ranges, formed originally of horizontal strata which had been forced up by internal pressure, must have been cracked and dislocated, the fissures widening outwards, while similar cracks must have been formed at the bases of the ranges; but the fissures would widen downwards, and would form channels and cavaties into which naphtha, formed in the depths to which the fissures descended, would rise and manifest itself, especially in localities where the surface had been sufficiently lowered by denudation or otherwise. It is in the lowest depths of these fissures that we must seek the laboratories in which the oil is formed; and once produced, it must inevitably rise to the surface, whether forced up by its own pent-up gases or vapours, or floated up by associated water. In some instances the oil, penetrating or soaking through the surface layers, loses its more volatile constituents by evaporation, and, in consequence, deposits of pitch, of carboniferous shales, and asphalte take place; in other cases, the oil, impregnating sands at a lower level, is often found under great pressure, and associated with forms of itself in a permanently gaseous state. This oil may be distributed widely according to the nature of the formations or the disturbances to which they have been subjected; but the presence of petroleum is not in any way connected with the geologiical age of the oil-bearing strata: it is simply the result of physical condition and of surface structure. The process of the formation of petroleum seems to be the following:—It is generally admitted that the crust of the earth is very thin in comparison with the diameter of the latter, and that this crust encloses soft or fluid substances, among which the carbides of iron and of other metals find a place. When, in consequence of cooling or some other cause, a fissure takes place through which a mountain range is protruded, the crust of the earth is bent, and at the foot of the hills fissures are formed; or, at any rate, the continuity of the rocky layers is disturbed, and they are rendered more or less porous, so that surface waters are able to make their way deep into the bowels of the earth, and to reach occasionally the heated deposits of metallic carbides, which may exist either in a separated condition or blended with other matter. Under such circumstances it is easy to see what must take place. Iron, or whatever other metal may be present, forms an oxide with the oxygen of the water; hydrogen is either set free or combined with the carbon which was associated with the metal, and becomes a volatile substance—that is, naphtha. The water which had penetrated down to the incandescent mass was changed into steam, a portion of which found its way through the porus substances with which the fissures were filled, and carried with it the vapours of the newly-formed hydrocarbons, and this mixture of vapours was condensed wholly or in part as soon as it reached the cooler strata. The chemical composition of the hydrocarbons produced will depend upon the conditions of temperature and pressure under which they are formed. It is obvious that these may vary between very wide limits, and hence it is that mineral oils, mineral pitch, ozokerit, and similar products differ so greatly from each other in the relative proportions of hydrogen and carbon. I may mention that artificial petroleum has been frequently prepared by a process analogous to that described above. It is needless to remark that Dr. Mendeleeff's views are not shared by every competent authority; nevertheless, the remarkable permanence of oil-wells, the apparently inexhaustible evolution of hydro-carbon gases in certain regions, almost forces one to believe that the hydrocarbon products must be forming as fast as they are consumed, that there is little danger of the demand ever exceeding the supply, and that there is every prospect of oil being found in almost every portion of the surface of the earth, especially in the vicinity of great geological disturbances. Improved methods of boring wells will enable greater depths to be reached; and it should be remembered that, apart from the cost of sinking a deep well, there is no extra expense in working at great depths, because the oil generally rises to the surface or near it. The extraordinary pressures, amounting to 300 lbs. per square inch, which have been measured in some wells, seem to me to yield conclusive evidence of the impermeability of the strata from under which the oil has been forced up, and tend to confirm the view that it must have been formed in regions far below any which could have contained organic remains.

ENGINEERING SOCIETY.

After alluding to the want of a standard horse power, the President said:—I have expressed an opinion that the numerous engineering societies which exist at this day have it in their power to promote the advancement of mechanical science in a notable manner by appointing research committees, or by aiding individual investigations from their abundant means. The North-East Coast Institution of Engineers and Shipbuilders have done good service in their endeavours to establish a practical measure of the power of marine engines, while the Institution of Mechanical Engineers has, for the last ten years, been steadily promoting researches of an eminently practical nature. Their expenditure has reached the handsome sum of £1,700, and their proceedings have been enriched with reports on the "Hardening, tempering, and annealing of steel," on the "Form of riveted joints," on "Friction at high velocities," on "Marine engine trials," and on the "Value of the steam jacket." The names of those who are acting on these committees are a guarantee that the investigations conducted by them will rank among the classical works of the profession, and will abundantly justify the liberal expenditure which has been incurred.

THE FORTH BRIDGE.

It is impossible to conclude the address which I have had the honour of delivering without an allusion to the most important structure which engineering skill and enterprise has ever attempted. The Forth Bridge is rapidly approaching completion, and on Saturday, September 14, Mr. Baker is to deliver a lecture, in which he will, no doubt, tell us when the great work is likely to be completed. I think that the members of this section belong sufficiently to the working classes to have a claim to admission to the lecture, and to hear from the lips of the creator of the bridge the story of its inception, of its progress, and his hopes as to its completion.

Sir William Thomson moved a vote of thanks to the president for his address, to which he said he had listened with thrilling interest. The necessities of the modern engineer led him to the very deepest questions of physics, and to those whose time and attention had been more devoted to the physical side of studies than to the practical, it must be very pleasant indeed to find that the engineers were brought so thoroughly into harmony with the work of the physical engineer. The president had dwelt upon one of the most important subjects in physical and engineering practice, that was the molecular construction of matter. The researches into force in modern artillery would contribute very largely indeed to the advancement of science. Might they not hope that the time would come when explosives in guns would be turned away from their present purpose, and that great guns would be used to demonstrate the effect of enormous pressures on the properties of matter in a purely scientific way? (Applause.) Concerning the durability of the petroleum supply, he had heard it said that the petroleum was understood to be produced low down in the earth, and not taken from organic matter. But he could not hold that view with any certainty after he had heard Mendelejeff's theory so beautifully put before them by Mr. Anderson. They were very much indebted to their president for his address, especially upon a subject of such tremendous importance as the origin and possible durability of the petroleum supply. (Applause.)

Sir George B. Bruce (London) seconded the motion, which was agreed to.

The President, in replying, said it had been stated in the newspapers that the petroleum supply of the Caucasus was becoming exhausted. If this were true, it would go far to upset his theory. But, by a strange coincidence, he had that morning received a letter from Professor Mendelejeff, in which he desired him to say that it was absolutely untrue. There was not the slightest falling off in the petroleum supply, and the rumour which had got into the papers was a mere Stock Exchange scheme, to make certain financial operations. (Applause.)

COMPRESSED AIR.

Professor Alexander B. W. Kennedy, University College, London, read a paper on "Experiments on the the Transmission of Power by Compressed Air: Popp's System." The author recently made somewhat extensive experiments in Paris in connexion with the compressed-air system at work there. This system originated in the distribution of air for the purpose of working pneumatic clocks. By degrees the air came into demand for motors, and the demand increased so rapidly that two years since plant capable of indicating more than 2,000 horse-power was put down in a "central station" at St. Fargeau, about 4½ miles from the centre of Paris. The air, compressed at six atmospheres of absolute pressure, is transmitted to Paris through 12-inch cast-iron mains, and is used for the working of considerably over 200 motors of powers varying from one-eighth to 25 horse-power nominal. The air, if sold by quantity, is measured through a fan meter, and its pressure is controlled at each motor by a reducing-valve. For all, except the smallest motors, the air, after leaving the reducing-valve, is passed through a heater (heated with coke), so as greatly to raise its temperature before use. The smaller sizes of motor used are rotary engines. All the more important ones, however, are simply ordinary steam-engines, working by compressed air instead of by steam. The final results as to air consumption, Mr. Kennedy found to be with the motor used about 890 cubic feet of air (measured at atmospheric pressure and temperature) per indicated horse-power per hour, if the air were not previously heated, and about 660 cubic feet when the heating stove was employed. This corresponds to a total indicated efficiency of transmission of about 50 per cent. He gave reason for believing that this efficiency, which is that now reached, may be raised to at least 55 per cent. without serious difficulty, in which case one indicated horse-power at the central station would give about 0·52 of a brake horse-power on a small motor four miles away from it. In conclusion, the author described the great advantages in convenience, in saving of space, in saving of insurance, and from a sanitary point of view, of compressed-air motors, and gave a summary of the purposes for which the power is actually used at present in Paris.

Sir Douglas Galton said he saw the installation of the system in Paris, and was extremely glad to find that the results of Professor Kennedy's investigations showed that the use of compressed air was really a matter which could be brought within the limits of practical applicability.

Sir Frederick Bramwell, ex-president of the association, spoke of a mode of transmitting power from a central source which was invented by the man to whom he was apprenticed 55 years ago, John Hague, who transmitted power, and did it very successfully indeed, by the opposite of compression—by a partially vacuous condition of the mains. He (Sir Frederick) believed in the efficacy of transmitting power by compressed air, and had advised its adoption in Birmingham.

Professor Wm. A. Unwin, Liverpool, did not doubt that compressed air could be successfully applied to cranes and lifts, and for the transmission of power in towns it had exceptional advantages as compared with water.

Mr. Stephenson, Durham, said that for 20 or 30 years he had been using compressed air in mines, and for this purpose there was nothing equal to it. He thought, however, that in towns petroleum engines would supersede all other modes of transmitting power.

Mr. W. H. Preece, chief electrician to the General Post Office, replying to an observation by Mr. Stephenson, said he never knew of anybody having been killed by electricity. People had been killed by wires, but that had almost invariably been due to the downright stupidity of the persons who had charge of the wires. He was an advocate of transmitting power by compressed air. In Newcastle, there was a pneumatic system, messages being regularly transmitted by this means between the post office and the quayside.

Professor Kennedy, in reply, said the vacuum system could not be applied to large powers. Compressed air was preferable to petroleum, for they got an engine in a small space under healthy conditions. It started when the cock was opened, and worked with the regularity of a steam engine.

WATER GAS.

Major-General Webber, of London, read a paper contributed by Mr. A. C. Humphreys, of Philadelphia, on "Water Gas." He said water gas was generally obtained by the decomposition of steam which had been brought into contact with incandescent carbon. The first reaction obtained was the formation of carbonic acid and the liberation of hydrogen. The carbonic acid was brought into contact with an additional quantity of incandescent carbon, from which it took up an equivalent and became carbonic oxide, so that there resulted theoretically a mixture of hydrogen and carbonic oxide in equal proportions. These gases had no light-giving properties, so that if they were to be used for illuminating purposes, they had either to be mixed with some hydro-carbon in a gaseous form, or they must be employed to raise to a white heat some solid substance, such as lime, magnesia, zirconium, lanthanium, platinum, &c. There were two methods of effecting the decomposition of steam, one intermittent and the other continuous. In the first a furnace of the cupola pattern was used, the fuel was raised to the desired temperature by a blast of air, which was shut off as soon as this was attained and steam was turned on, the blowing up and the injection of steam succeeding one another intermittently. In the continuous process the decomposing carbon was either placed in retorts heated externally, and steam was passed through uninterruptedly, or a cupola furnace was employed, and steam and air were forced through in continuously, but the latter process had the disadvantage of the resultant gases being associated with a great deal of nitrogen, so that after enrichment with hydrocarbons the flame was "tender," was easily blown out, and smoked on small provocation. In 1874, there was practically no water gas made in the United States or in Canada; and now, out of 1,150 gas works, 300 were on the water gas system. With the quantity of gas produced, the quality was improved greatly, and there is now probably no gas which was better adapted for distribution in extremely cold climates than water gas made in a modern plant of certain construction, and that, too, from ordinary furnace coal, gas coke, or crude oil. He proceeded to consider the theory of the processes in detail, and calculated the distribution of heat throughout the reactions, remarking that it was only by the application of a water gas system of manufacture that the whole of the carbon used could be converted into gas. He thought the end of fuel gas was approaching.

Sir **Isaac Lowthian Bell** said he would say nothing about water gas as an illuminant, because he know nothing. But it was stated in the paper that the end of fuel gas was near. To this he took entire exception. To his mind a greater philosophic fallacy than this could not be propounded. He expressed his disbelief that anything could be gained from a calorific point of view by converting fuel into water gas.

General **Webber** said that illuminating gas in England was so cheap that, until only a short while ago, nobody thought of competing with it. But it was different in America.

Mr. A. E. **Fletcher**, London, pointed out that an advantage in the use of coal was its chemical value, as regarded what were called by-products. About fifteen millions sterling worth of coal was treated every year, and £1,500,000 worth of sulphate of ammonia was produced, and this would doubtless be extended.

SECTION H.—ANTHROPOLOGY.

President.—Professor Sir W. Turner, M.B., LL.D., F.R.S.L. and E.

Vice-Presidents.—J. Evans, D.C.L., LL.D., V.P.R.S., F.L.S., F.G.S.; Francis Galton, M.A., F.R.S.; Professor G. H. Philipson, M.A., M.D., D.C.L., F.R.C.P.; Gen. Pitt-Rivers, D.C.L., F.R.S.

Secretaries.—G. W. Bloxam, M.A., F.L.S. (Recorder); J. G. Garson, M.D., F.Z.S., V.P.A.I.; J. Rutherford Morison, M.D., F.R.C.S.

Place of meeting, the Public Library.

ADDRESS BY SIR WM. TURNER.

BODILY EFFICIENCY IN EXAMINATIONS OF PUBLIC SERVANTS.

The proceedings commenced by Mr. **Francis Galton**, F.R.S., London, reading a paper "On the advisability of assigning marks for bodily efficiency in the examinations of candidates for public services," which was followed with another paper by the same gentleman "On the principle and methods of assigning marks for bodily efficiency." The lecturer, at the outset, referred to a paragraph which occurred in the recently-issued report of H.M. Civil Service Commissioners, and which pointed out that it was thought advisable some years ago to consider the possibility of making physical qualifications an element in the competitions forentrance into Woolwich and Sandhurst. A scheme of competition was drawn up, but was ultimately laid aside, as the authorities did not think it necessary to introduce such a competition, being satisfied with the physique of the young men who came to them for examination. At the same time, the authorities stated "that, should any department in the public service be desirous of testing the physical qualifications of its officers more severely than at present, we anticipate that there would be no more difficulty in determining the relative capacities of the individual candidates in this respect than was experienced in the literary examinations." The lecturer then proceeded to show diagrams showing the ease with which relative rank could be determined on scales and grades, and pointed out that the marks, as at present, of the candidates whose places lay near the dividing line between success and failure ran pretty evenly; therefore it was contended that the State would obtain better servants if such moderate marks were allowed for physical qualifications as to ensure the selection of the most efficient in body from among those who were nearly on a par intellectually. — In the discussion which followed, Mr. Summerville, one of the Eton masters, spoke of experiments made at Eton College.—The President said all concerned in education knew how important it was that in estimating the power of a man they had to consider what he could do in the world, and to take into consideration more than his brain power; and it had often been pressed upon the authorities engaged in examination for public services that there should be more recognition made of the candidate's physical as well as his mental power. Mr. Galton had shown how that could be done. Those papers proved that in that section they were not concerned solely in speculative matters, but that they tried to make their science practical. (Applause.)—Professor Flower, in the course of a few remarks, said the question affected the future welfare of the country, and was one to which a great deal of attention had been directed. Dissatisfaction had been expressed at the present system of examination, but he did not think there was any chance of abolishing it, the reason being that no one had suggested a better system. It therefore behoved them to try to improve that system, and to bring it as much as possible into the requirements for which it was intended. He hoped Mr. Galton's suggestions would be considered, and carefully applied wherever they could be. (Applause.)

PRESIDENT'S ADDRESS.

Prof. Sir W. **Turner**, president of the Anthropological Section, commenced his address with the following interesting local reminiscences:—Twenty-six years have passed by since the British Association for the Advancement of Science last assembled in this city. Many of the incidents of that meeting are still fresh in my memory, the more vividly, perhaps, because it was the first meeting of the Association that I had attended. The weather, so important a factor in most of our functions, was dry and bright. The visitor, instead of being enshrouded in that canopy of mist and smoke which so often meets the traveller as he approaches your city, was greeted with light and sunshine. The cordial welcome and reception so freely granted by the community, and more especially the princely yet gracious hospitality exercised by the president, your eminent townsman, now Lord Armstrong, are all deeply imprinted on my memory. But, apart from these attractions, which added so much to the amenities of the occasion, the meeting was one of deep interest to all those members and associates who were engaged in biological study. Lyell's famous book on the "Antiquity of Man" had been published shortly before. The essays on the "Origin of Species" by natural selection, by Charles Darwin and Alfred Russell Wallace, had appeared only five years earlier in the Journal of the Linnæan Society, and in 1859 Darwin's treatise on the "Origin of Species," in which its illustrious author summarised the facts he had collected, and the conclusions at which he had arrived had been published. Although no President of the British Association had up to that time given his adhesion to the new theory, yet it was clear that men were beginning to see, in many instances perhaps only dimly, how the theory of evolution by natural selection was destined to work a remarkable change, amounting almost to a revolution, in our conceptions of biological questions generally, and their applicability to the study of man. At that time Anthropology had not assumed so definite a position in the work of the association as it now possesses. Neither a department, nor a section, was devoted to it, and the subjects which it embraces were scattered abroad, either in the department of Anatomy and Physiology, in the section of Geography and Ethnology, in that of Geology, or in that of Statistics. It is true that a vigorous attempt was made about that time to give it a more independent position, but it was not until the association met in Nottingham, in 1866, that it was assigned a definite department, and at the Montreal meeting, in 1884, Anthropology assumed the dignity of a section. As presiding over the proceedings of the section on this occasion, it is a part of my duty to open its public business with an address. I have chosen the subject of heredity, by which I mean that special property through which the peculiarities of an organism are transmitted to its descendants throughout successive generations, so that the offspring, in their main features, resemble their parents. The subject of

HEREDITY.

if I may say so, is in the air at the present time. The prominence which it has assumed of late years is in connexion with its bearing on the Darwinian theory of natural selection, and, consequently, biologists generally have had their attention directed to it. But in its relation to man, his structure, functions, and diseases, it has long occupied a prominent position in the minds of anatomists, physiologists, and physicians. That certain diseases, for example, are hereditary was recognised by Hippocrates, who stated generally that hereditary diseases are difficult to remove, and the influence which the hereditary transmission of disease exercises upon the duration of life is the subject of a chapter in numerous works on practical medicine, and forms an important element in the valuation of lives for life insurance.

PHYSICAL BASIS FOR HEREDITY.

The first aspect of the question which has to be determined is whether any physical basis can be found for heredity. The careful study, especially during the last few years, of the development of a number of species of animals, mostly but not exclusively amongst the invertebrata, has established the important fact that the young animal arises by the fusion within the egg or germ-cell of an extremely minute particle, derived from the male parent, with an almost equally minute particle derived from the germ-cell produced by the female parent. The starting-point of each individual organism—*i.e.* of each new generation—is therefore the segmentation nucleus. Every cell in the adult body is derived by descent from that nucleus through repeated division. As the segmentation nucleus is formed by the fusion of material derived from both parents, a physical continuity is established between parents and offspring. But this physical continuity carries with it certain properties which cause the offspring to reproduce, not only the bodily configuration of the parent, but other characters. In the case of man we find along with the family likeness in form and features a correspondence in temperament and disposition, in the habits and mode of life, and sometimes in the tendency to particular diseases. This transmission of characters from parent to offspring is summarised in the well-known expression that "like begets like," and it rests upon a physical basis. In considering the question of how new individuals are produced, one must keep in mind that it is not every cell in the body which can act as a centre of reproduction for a new generation, but that certain cells, which we name germ-cells and sperm-cells, are set aside for that purpose. These cells, destined for the production of the next generation, form but a small proportion of the body of the animal in which they are situated. They are, as a rule, marked off from the rest of the cells of its body at an early period of development. The exact stage at which they become specially differentiated for reproductive purposes varies, however, in different organisms. The problem, therefore, for consideration is the mode in which these germ or reproductive cells become influenced, so that after been isolated from the cells which make up the bulk of the body of the parent they can transmit to the offspring the characters of the parent organism. Various speculations and theories have been advanced by way of explanation. The well-known theory of Pangenesis, which Charles Darwin with characteristic moderation put forward as merely a provisional hypothesis, assumes that *gemmules* are thrown off from each different cell or unit throughout the body which retain the characters of the cells from which they spring; that the gemmules aggregate themselves either to form or to become included within the reproductive cells; and that in this manner they and the characters which they convey are capable of being transmitted in a dormant state to successive generations, and to reproduce in them the likeness of their parents, grandparents, and still older ancestors. In 1872, and four years afterwards, in 1876, Mr. Francis Galton published most suggestive papers on

KINSHIP AND HEREDITY.

In the latter of these papers he developed the idea that "the sum total of the germs, gemmules, or whatever they may be called," which are to be found in the newly fertilised ovum. constitute a *stirp*, or root. That the germs which make up the stirp consist of two groups—the one which develops into the bodily structure of the individual, and which constitutes, therefore, the personal structure; the other, which remains latent in the individual, and forms, as it were, an undeveloped residuum. That it is from these latent or residual germs that the sexual elements intended for producing the next generation are derived, and that these germs exercise a predominance in matters of heredity. Further, that the cells which make up the personal structure of the body of the individual exercise only in a very faint degree any influence on the reproductive cells, so that any modifications acquired by the individual are barely, if at all, inherited by the offspring. Weismann asks the fundamental question, "How is it that a single cell of the body can contain within itself all the hereditary tendencies of the whole organism?" He states that in his belief the germ-cell, so far as its essential and characteristic substance is concerned, is not derived at all from the body of the individual in which it is produced, but directly from the parent germ-cell from which the individual has also arisen. He calls his theory the continuity of the germ-plasm, and he bases it upon the supposition that in each individual a portion of the specific germ-plasm derived from the germ-cell of the parent is not used up in the construction of the body of that individual, but is reserved unchanged for the formation of the germ-cells of the succeeding generation. In further exposition of his theory, Weismann goes on to say, as the process of fertilisation is attended by a conjugation of the nuclei of the reproductive cells—the pronuclei referred to in an earlier part of this address—that the nuclear substance must be the sole bearer of hereditary tendencies. Each of the two uniting nuclei would contain the germ-plasm of one parent, and this germ-plasm also would contain that of the grandparents as well as that of all previous generations. Weismann does not absolutely assert that an organism cannot exercise a modifying influence upon the germ-cells within it; yet he limits this influence to such slight effect as that which would arise from the nutrition and growth of the individual, and the reaction of the germ-cell upon changes of nutrition caused by alteration in growth at the periphery, leading to some change in the size, number, and arrangements of its molecular units. But he throws great doubt upon the existence of such a reaction, and he, more emphatically than Mr. Galton, argues against the idea that the cells which make up the somatic or personal structure of the individual exercise any influence on the reproductive cells. From his point of view the structural or other properties which characterise a family, a race, or a species are derived solely from the reproductive cells through continuity of their germ-plasm, and are not liable to modification by the action on them of the organs or tissues of the body of the individual organism in which they are situated. The central idea of heredity is permanency; that like begets like, or, as Mr. Galton more fitly puts it, that "like *tends* to produce like." But though the offspring conform with their parents in all their main characteristics, yet, as every one knows, the child is not absolutely like its parents, but possesses its own character, its own individuality. It is easy for any one to recognise that differences exist amongst men when he compares one individual with another; but it is equally easy for those who make a special study of animals to recognise individual differences in them also. Thus a pigeon or canary fancier distinguishes without fail the various birds in his flock, and a shepherd knows every sheep under his charge. But the anatomist tells us that these differences are more than superficial—that they also pervade the internal structure of the body. Intimately associated, therefore, with the conception of heredity—that is, the transmission of characters common to both parent and offspring—is that of variability—that is, the appearance in an organism of certain characters which are unlike those possessed by its parents. Heredity, therefore, may be defined as the perpetuation of the like; variability, as the production of the unlike.

HOW VARIETIES ARISE.

And now we may ask, Is it possible to offer any feasible explanation of the mode in which variations in organic structure take their rise in the course of development of an individual organism? Anything that one may say on this head is of course a matter of speculation, but certain facts may be adduced as offering a basis for the construction of an hypothesis, and on this matter Professor Weismann makes a number of ingenious suggestions. Minute though the segmentation nucleus is, yet microscopic research has shown that it is not a homogeneous structureless body, but is built up of different parts. Most noteworthy are the presence of extremely delicate threads or fibrils, called the *chromatin filaments*, which are either coiled on each other, or intersect to form a network-like arrangement. In the meshes of this network a viscous—and, so far as we yet know, structureless—substance is situated. Before the process of division begins in the segmentation nucleus these filaments swell up and then proceed to arrange themselves at first into one and then into two star-like figures before the actual division of the nucleus takes place. It is obvious, therefore, that the molecules which enter into the formation of the segmentation nucleus can move within its substance, and can undergo a readjustment in size and form and position. But this readjustment of material is, without doubt, not limited to those relatively coarse particles which can be seen and examined under the microscope, but applies to the entire molecular structure of the segmentation nucleus. Now it must be remembered that the cells of the embryo from which all the tissues and organs of the adult body are derived are themselves descendants of the segmentation nucleus, and they will doubtless inherit from it both the power of transmitting definite characters and a certain capacity for readjustment both of their constituent materials and the relative positions which they may assume towards each other. One might conceive, therefore, that if in a succession of organisms derived from common ancestors the molecular particles were to be of the same composition and to arrange themselves in the segmentation necleus and in the cells derived from it on the same lines, these successive generations would be alike; but if the lines of adjustment and the molecular constitution were to vary in the different generations, then the products would not be quite the same. Variations in structure, and to some extent also in the construction of parts, would arise, and the unlike would be produced. In this connexion it is also to be kept in mind that in the higher organisms, and, indeed, in multicellular organisms generally, an individual is derived, not from one parent only, but from two parents. If one parent were to contribute a larger proportion than the other to the formation of a particular organism, then the balance would be disturbed, the offspring in its character would incline more to one parent than to the other, according to the proportion contributed by each, and a greater scope for the production of variations would be provided. These differences would be increased in number in the course of generations, owing to new combinations of individual characters arising in each generation. As long as the variations which are produced in an organism are collectively within a certain limitation, they are merely individual variations, and express the range within which such an organism, though exhibiting differences from its neighbours, may yet be classed along with them in the same species. It is in this sense that I have discussed the term variability up to the present stage of this address. Thus all those varieties of mankind which, on account of differences in the colour of the skin, we speak of as the white, black, yellow races and red-skins are men, and they all belong to that species which the zoologists term *Homo sapiens*.

THE DARWINIAN THEORY.

But the subject of variability cannot, in the present state of science, be confined in its discussion to the production of individual variations within the limitations of a common species. Since Charles Darwin enunciated the proposition that favourable variations would tend to be preserved, and unfavourable ones to be destroyed, and that the result of this double action, by the accumulation of minute existing differences, would be the formation of new species by a process of natural selection, this subject has attained a much wider scope, has acquired increased importance, and has formed the basis of many ingenious speculations and hypotheses. As variations, when once they have arisen, may be hereditarily transmitted, the Darwinian theory might be defined as heredity modified and influenced by variability.

HEREDITARY DISEASE.

The President then gave instances of congenital malformations, and proceeded:—Malformations arise, as a rule, before the time of birth, during the early development of the individual; but there is an important class of cases, in which the evidence for hereditary transmission is more or less strong, which may not exhibit their peculiarities until months, or even years, after the birth of the individual. This class is spoken of as hereditary diseases, and the structural and functional changes which they produce exercise most momentous influences. Sometimes these diseases may occasion changes in the tissues and organs of the body of considerable magnitude, but at other times the alteration is much more subtle, is molecular in its character, requires the microscope for its determination, or is even incapable of being recognised by that instrument.

CONSUMPTION.

Had one been discussing the subject of hereditary disease twenty years ago, the first example probably that would have been adduced would have been tuberculosis, but the additions to our knowledge of late years throw some doubt upon its hereditary character. There can, of course, be no question that tubercular disease propagates itself in numerous families from generation to generation, and that such families show a special susceptibility or tendency to this disease in one or other of its forms. But whilst fully admitting the predisposition to it which exists in certain families, there is reason to think that the structural disease itself is not hereditarily transmitted, but that it is directly excited in each individual in whom it appears by a process of external infection due to the action of the tubercle bacillus. Still if the disease itself be not inherited, a particular temperament which renders the constitution liable to be attacked by it is capable of hereditary transmission.

CANCER.

Sir James Paget, when writing on the subject of cancer, gives statistics to show that about a quarter of the persons affected were aware of the existence of the same disease in other members of their family, and he cites particular instances in which cancer was present in two and even four generations. He had no doubt that the disease can be inherited—not, he says, that, strictly speaking, cancer or cancerous material is transmitted, but a tendency to the production of those conditions which will finally manifest themselves in a cancerous growth. The germ from the cancerous parent must be so far different from the normal as after the lapse of years to engender the cancerous condition.

GOUT AND RHEUMATISM.

Heredity is also one of the most powerful factors in the production of those affections which we call gout and rheumatism. Sir Dyce Duckworth, the latest systematic writer on gout, states that in those families whose histories are the most complete and trustworthy the influence is strongly shown, and occurs in from 50 to 75 per cent. of the cases; further, that the children of gouty parents show signs of articular gout at an age when they have not assumed those habits of life and peculiarities of diet which are regarded as the existing causes of the disease.

CONSANGUINITY.

In connexion with the tendency to the transmissibility of either congenial malformations, or diseases, consanguinity in the parents, although by no means a constant occurrence, is a factor which in many cases must be taken into consideration. If we could conceive both parents to be physiologically perfect, then it may be presumed that the offspring would be also; but if there be a departure in one parent from the plane of physiological perfection, then it may safely be assumed that either the immediate offspring or a succeeding generation will display a corresponding departure in a greater or less degree. Should both parents be physiologically imperfect, we may expect the imperfections, if they are of a like nature, to be intensified in the children. It is in this respect, therefore, that the risk of consanguineous marriages arises, for no family can lay claim to physiological perfection. When we speak of tendencies, susceptibilities, proclivities, or predisposition to the transmission of characters, whether they be normal or pathological, we employ terms which undoubtedly have a certain vagueness. We are as yet quite unable to recognise, by observation alone, in the germ-plasm any structural change which would enable us to say that a particular tendency or susceptibility will be manifested in an organism derived from it. We can only determine this by following out the life-history of the individual. Still it is not the less true that these terms express a something of the importance of which we are all conscious. So far as man is concerned, the evidence in favour of a tendency to the transmission of both structural and functional modifications which are either of dis-service, or positively injurious, or both, is quite as capable of proof as that for the transmission of characters which are likely to be of service. Hence useless as well as useful characters may be selected and transmitted hereditarily.

TRANSMISSION OF CHARACTER.

Much has been said and written during the last few years of the transmission from parents to offspring of characters which have been "acquired" by the parent, so that I cannot altogether omit some reference to this subject. It will conduce to one's clearness of perception of this much-discussed question if one defines at the outset in what sense the term "acquired characters" is employed; and it is the more advisable that this should be done, as the expression has not always been used with the same signification. This term may be used in a wide or in a more restricted sense. In its wider meaning it may cover all the characters which make their first appearance in an individual, and which are not found in its parents, in whatever way they have arisen :—

1st. Whether their origin be due to such molecular changes in the germ-plasm as may be called spontaneous, leading to such an alteration in its character as may produce a new variation ; or,

2nd. Whether their origin be accidental, or due to habits, or to the nature of the surroundings, such as climate, food, &c.

Professor Weismann has pointed out with great force the necessity of distinguishing between these two kinds of "acquired characters," and he has suggested two terms, the employment of which may keep before us how important it is that these different modes of origin should be recognised. Characters which are produced in the germ-plasm itself by natural selection, and all other characters which result from this latter cause, he names *blastogenic*. He further maintains that all blastogenic characters can be transmitted ; and in this conclusion, doubtless, most persons will agree with him. On the other hand, he uses the term *somatogenic* to express those characters which first appear in the body itself, and which follow from the reaction of the *soma* under direct external influences. He includes under this head the effects of mutilation, the changes which follow from increased or diminished performance of function, those directly due to nutrition, and any of the other direct external influences which act upon the body. He further maintains that the somatogenic characters are not capable of transmission from parent to offspring, and he suggests that in future discussions on this subject the term "acquired characters" should be restricted to those which are somatogenic. I would express my agreement with much that has been said by Professor Weismann on the want of sufficient evidence to justify the statement that a mutilation which has affected a parent can be transmitted to the offspring. It is, I suppose, within the range of knowledge of most of us that children born of parents who have lost an eye, an arm, or a leg, come into the world with the full complement of eyes and limbs. The mutilation of the parent has not affected the offspring; and one would, indeed, scarcely expect to find that such gross visible losses of parts as take place when a limb is removed by an accident or surgical operation should be repeated in the offspring. But a similar remark is also applicable to such minor mutilations as scars, of the transmission of which to the offspring, though it has been stoutly contended for by some, yet seems not to be supported by sufficiently definite instances. I do not refer to the influence on the offspring of impressions made on the senses and nervous system of the mother, the first statement of the effects of which we find in the book of Genesis, where Jacob set peeled rods before the flocks in order to influence the colour and markings of their young; though I may state that I have heard agriculturists relate instances from their own experience which they regarded as bearing out the view that impressions acting through the mother do influence her offspring. But I refer to what is an axiom with those who breed any particular kind of stock, that to keep the strain pure, there must be no admixture with stock of another blood. For example, if a shorthorned cow has a calf by a Highland sire, that calf, of course, exhibits characters which are those of both its parents. But future calves which the same cow may have when their sires have been of the shorthorned blood, may, in addition to shorthorn characters, have others which are not shorthorned but Highland. The most noteworthy instance of this transmission of characters acquired from one sire through the same mother to her offspring by other sires is that given in the often-quoted experiment by a former Lord Morton. An Arabian mare in his possession produced a hybrid the sire of which was a quagga, and the young one was marked by zebra-like stripes. But the same Arabian had subsequently two foals, the sire of which was an Arab horse, and these also showed some zebra-like markings. How, then, did these markings characteristic of a very different animal arise in these foals, both parents of which were Arabians? I can imagine it being said that this was a case of reversion to a very remote striped ancestor, common alike to the horse and the quagga. But, to my mind no such far-fetched and hypothetical explanation is necessary. The cause of the appearance of the stripes seems to me to be much nearer and more obvious. I believe that the mother had acquired during her prolonged gestation with the hybrid, the power of transmitting quagga-like characters from it, owing to the interchange of material which had taken place between them in connexion with the nutrition of the young one. For it must be kept in mind that in placental mammals an interchange of material takes place in opposite directions, from the young to the mother as well as from the mother to the young. In this way the germ-plasm of the mother, belonging to ova which had not yet matured, had become modified whilst still lodged in the ovary. This acquired modification had influenced her future offspring, derived from that germ-plasm, so that they in their turn, though in a more diluted form, exhibited zebra-like markings. If this explanation be correct, then we have an illustration of the germ-plasm having been directly influenced by the soma, and of somatogenic acquired characters having been transmitted. Those who uphold the view that characters acquired by the soma cannot be transmitted from parents to offspring undoubtedly draw so large a cheque on the bank of hypothesis that one finds it difficult, if not impossible, to honour it. All biologists will, I suppose, accept the proposition that the individual soma is influenced or modified by its environments or surroundings. Now, if on the basis of this proposition the theory be grafted that modifications or variations thus produced are capable of so affecting the germ-plasm of the individual in whom the variation arises as to be transmitted to its offspring —and I have already given cases in point—then such variations might be perpetuated. If the modification is of service, then presumably it will add to the vitability of the individual, and through the interaction between the soma and the germ-plasm, in connexion with their respective nutritive changes, will so affect the latter as to lead to its being transmitted to the offspring. From this point of view the environment would, as it were, determine and regulate the nature of those variations which are to become hereditary, and the possibility of variations arising which are likely to prove useful becomes greater than on the theory that the soma exercises no influence on the germ-plasm. Hence I am unable to accept the proposition that somatogenic characters are not transmitted, and I cannot but think that they form an important factor in the production of hereditary characters. By accepting the theory that somatogenic characters are transmitted we obtain a more ready explanation, how men belonging to a race living in one climate or part of the globe can adapt themselves to a climate of a different kind. The physical aspect of the question, although of vast importance and interest, yet by no means covers the whole ground of man's nature, for in him we recognise the presence of an element beyond and above his animal framework. Man is also endowed with a spiritual nature. He possesses a conscious responsibility which enables him to control his animal nature, to exercise a discriminating power over his actions, and which places him on a far higher and altogether different platform than that occupied by the beasts which perish. The kind of evolution which we are to hope and strive for in him is the perfecting of this spiritual nature, so that the standard of the whole human race may be elevated and brought into more harmonious relation with that which is holy and divine.

Professor **FLOWER**, in proposing a vote of thanks to Sir W. Turner for his address, said he knew of no more important subject than that of heredity. He was glad to hear the conclusion Sir William Turner had come to. It was one in which there seemed to be many difficulties in producing specific proof which accorded with their general experience. When they were entirely negative, as some of their observations must be, they threw them back into a state of great confusion as to how the great changes and modifications had been produced. It was a question of great importance in social and moral evolution.

Mr. **FRANCIS GALTON**, in seconding the resolution, said the subject of the address, "heredity," would be continued on the following day in Section D.

CIVILISATION AND THE DECAY OF TEETH.

A paper "On the Early Failure of pairs of Grinding Teeth," was read by W. **WILBERFORCE SMITH**. The author gave the results of the examination of 160 persons—all dwellers in London, and composed of shop-women, of physician's out-patients, and of a group of young men forming a Mutual Improvement Society. These results tended to indicate that when the grinding-teeth, premolars, and molars were considered as opponent pairs, the average loss was far greater than casual observation of the front of the mouth would be likely to suggest, and that it progressed rapidly in young adults, *pari passu* with age, which was the essential modifying condition. The loss was much greater in molar than in premolar pairs of teeth, just as premolars were in their turn more liable than front teeth (canines and incisors). These facts might be compared with various others tending to the conclusion that the lessened wear and friction in the grinding-teeth of civilised races was a predisposing cause of decay.

WISDOM TEETH.

In the absence of Dr. Ridolfo Livi, a paper on "The Development of the Wisdom Teeth" was read by Dr. J. G. **GARSON**. The paper dealt with observations made in 1885 and 1886 by Dr. Livi in the military districts of Mouza and Ancona. In that time he was able to note only the number of the teeth existing in each mouth, without calculating their respective position in the dental arch. Yet even this simple observation, Dr. Livi stated, if combined with others that the military surgeon in Italy was by regulation obliged to make, might lead to some useful result on that point, the importance of which in the question of the hierarchy of the human races was first divined by the great Darwin,

LEFT-LEGGEDNESS.

The next paper was on "Left-leggedness," read by Dr. W. K. **SIBLEY**, which said that Professor Ball in "Le Dualisme Cérébral" speaks of man as a right-handed animal. Being right-handed, it is popularly assumed that he is also right-legged ; but this does not appear to be the case. Standing working with the right hand there is a tendency to use the left leg for balance. Many people find less exertion in going round circles to the right than to the left ; race-paths are nearly always made for running in circles to the right. So the majority of movements are more readily performed to the right, as dancing, running, &c. The rule in walking is to keep to the right, and this appears to be almost universal. It is more natural to bear to the right. Of a large number of people from the better-educated classes asked about the existence of the rule, only 67 per cent. males and 53 per cent. females were aware of the rule ; the large majority obey it unconsciously in walking. Crowds tend to bear to the right. The left leg being the stronger, it is more readily brought into action ; hence troops start off with the left foot ; it is the foot which is placed into the stirrup of the saddle or step of bicycle in mounting ; so the left is the foot which a man takes off from in jumping. The experiments of Mr. G. H. Darwin blindfolding boys and telling them to walk straight, the right-handed one diverged to the right, and *vice versa.* From measurements of Dr. Garson of the skeletons of the two legs, in 54·3 per cent., the left was the longer and 35·8 the right. For measurements of the feet the author collected the drawings and measurements of 200 pairs, for which he is indebted to the courtesy of Mr. Parker, of Oxford Street, with the result that in 44 per cent. the left was longer, in 21·5 per cent. the right, and in 34·5 per cent. they were the same size. Measurement at the first joint gave 56 per cent. left larger, and at the instep 42·5 per cent. From the table of the figures it is observed that the left foot is more frequently the larger in the male than female sex, and the percentage of feet of the same size is greater in the female. The percentage of the right larger than the left is very constant, whereas the numbers of the left larger and those in which both feet were the same size are much more variable. Man, being naturally or artificially right-handed and left-legged, tends unconsciously to bear to the right ; lower animals on the other hand, appear nearly always to circle to the left.

THE OCCASIONAL EIGHTH TRUE RIB.

Professor D. J. **CUNNINGHAM** read a paper on "The occasional eighth true rib in man, and its relation to right-handedness." In the course of his remarks he said that there were seven ribs attached to the sternum as a rule on each side, but occasionally an eighth rib was attached. Those attached they called true, and those unattached were known as false ribs. Nearly 70 subjects had been examined—42 females and 21 males, and an eighth true rib was found in 20 per cent. In five, this eighth true rib was present on both sides, and in nine it was present on one side only, and that the right side, and only in one on the left side. He drew attention to the marked preference it seemed to have for the right side, and he believed it was due to right-handedness.

THE ERECTNESS OF MAN AS COMPARED WITH APES.

On the subject of "The proportion of bone to cartilage in the lumbar section of the vertebral column in the apes and in different races of men," Professor Cunningham said he desired to show some of the modifications which showed the result of the erect posture of man, and in looking at the vertical column, because it was in it that he especially looked for these modifications, there was no part in which they would expect to find such modifications more marked than in the lumbar region—the region of the loins, because it was upon this a great part of the weight of the limbs and trunk fell. If they examined the bodies of the lumbar vertebræ (which supported the weight of the trunk in man) in a number of ainmals, they found that in quadrupeds these bodies were long, narrow, and rod-like, placed one in front of the other, whereas in man they found that the bodies were short, broad, and disc-like, so as to widen the pillar of support. But the point of interest in this was that the gradations between these rod-like vertebræ and the disc-like body of vertebræ could be traced step by step as they passed up through the apes. After considering these acts, he began to think it possible that similar distinctions might be denoted in some of the lower races. A short time ago he broached the subject in an imperfect way; since then he had had opportunities of examining the skeletons in the museum of the Royal College of Surgeons, with the result that he had brought forward more evidence in support of the matter.

A short discussion, in which the President and Mr. Symington took part, followed.

Professor Cunningham also exhibited the models of heads of an old man, said to be 106 years old, and of a young orang-outang, with the brains exposed *in situ*.

MEETING OF DELEGATES.

In the afternoon a meeting of delegates was held at the New Assembly Rooms, Section C, under the presidency of Sir F. Galton.—The Chairman said it must be a satisfaction to the delegates that, by the utility of their proceedings, and the business-like way in which such proceedings were conducted, they were gradually growing into an important and integral part of the British Association. He thought it would be better for them to follow almost precisely the precedent of last year—that was, that he should begin by moving, in order to save time, that the report of the correspondence committees of the society to the general committee, copies of which had been distributed, should be taken as read. (Hear, hear.) He would now invite the delegates to make any statements respecting the work done by the committees appointed last year, or in connexion with other subjects referred to in the report. He begged them clearly to understand that no paper could be accepted there such as ought to be read in the sections. What they had to do was to give effect to what was proposed in the sections themselves, and also to deliberate on matters connected with the working, the harmonious working, of their several societies.

Mr. W. Grey (Section E.) said that last year they determined to endeavour to make a catalogue of all their ancient monuments and settlements. The Belfast Naturalists' Field Club had commenced such a catalogue in Ireland, in accordance with the recognised code of signals adopted by the International Congress of Archæologist somes years ago. The counties of Antrim and Down had been dealt with, and Mr. Grey displayed for the information of the delegates maps of these counties showing the distribution of pre-historic remains and ancient settlements. Any first attempt at cataloguing would be merely tentative and preliminary, and therefore he had adopted a method which he hoped would meet with their approval, of stating on each sheet where the site occurred and its distance in inches north and south.

Dr. Evans said the Society of Antiquaries was taking an archæological index and survey of the whole of England. In their maps they proposed to show not only the pre-historic, but the Saxon and Roman remains, and they were appealing to the different archæological societies throughout the country to aid them in carrying out that survey. The survey of the county of Kent had already been published, and would prove a most useful addition to the archæological knowledge of that county.

The Rev. E. P. Knubley, speaking on behalf of the Yorkshire Naturalists' Union, referred to the Boulder Committee, which had been doing very good work, and had submitted some fifty reports to the British Association, and to the Yorkshire Fossil Floral Committee, which worked on the same lines as the British Association Committee, and then proposed the formation of a committee to arrange for a collection of photographic views illustrating the geological features of each county in the United Kingdom, with Professor Bonny as president, and that a grant of £5 be applied for on account of such committee.

The Chairman held that such a resolution could not be brought before that meeting. They could not override the business of the sections.

Mr. Knubley: Would this override the business of the sections?

The Chairman: Yes.

Dr. Evans suggested that the matter should be referred to Section C.

Mr. Jeffs said he had several photographs which he would be glad to show to any gentlemen who might feel interested in seeing them.

The suggestion to refer the subject to Section C was adopted.

Prof. Lebour spoke of the work of the Earth Tremor Committee, and said the spot selected for the instruments was too near the sea, and not suitable for the experiments. They were having a new set of instruments made, and placed in another position. They were just ready for observation, but no observation had yet been made.

In reply to questions, Prof. Lebour said that two instruments would be placed underground and two on the surface, so that for the first time the observations would be taken simultaneously. The readings were automatic, and taken continuously.

This concluded the proceedings.

LIST OF THE DELEGATES.

The following is a list of the delegates, with their hosts, and also of the foreign gentlemen attending the meeting of the Association:—

DELEGATES.

Bath Natural History and Antiquarian Field Club—Rev. H. H. Winwood, M.A., F.G.S.
Belfast Naturalists' Field Club—Wm. Gray, M.R.I.A.
Belfast Natural History and Philosophical Society—John Brown.
Birmingham Natural History and Microscopical Society—Charles Pumphrey.
Birmingham Philosophical Society—Prof. B. C. A. Windle, M.D.
Cardiff Naturalists' Society—Peter Price,
Chester Society of Natural Science..W. P. J. Fawcus, C.E.
Chesterfield and Midland Counties Institution of Engineers—W. F. Howard, Assoc. M. Inst. C.E.
Croydon Microscopical and Natural History Club—Thomas Cushing, F.R.A.S.
Cumberland and Westmorland Association for the Advancement of Literature and Science—J. Goodchild, F.G.S.
East Kent Natural History Society—A. S. Reid, M.A., F.G.S.
East of Scotland Union of Naturalists' Societies—Robert Brown, R.N.
Essex Field Club—W. White
Geological Society of Glasgow—D. Corse Glen, F.G.S.
Natural History Society of Glasgow—Prof. F. O. Bower M.A., D.Sc.
Philosophical Society of Glasgow—Dr H. Muirhead
Hertfordshire Natural History Society and Field Club—Dr John Evans, F.R.S.
Isle of Man Natural History and Antiquarian Society—His Honour Deemster Gill
Leeds Geological Association—S. A. Adamson, F.G.S,
Liverpool Microscopical Society—J. C. Thompson, F.L.S.
Malton Field Naturalists' and Scientific Society—M. B. Slater, F.L.S.
Manchester Geographical Society—Eli Sowerbutts
Manchester Geological Society—Mark Stirrup, F.G.S.
North of England Institute of Mining and Mechanical Engineers—Prof. G. A. Lebour, M.A., F.G.S.
North Staffordshire Naturalists' Field Club—Dr. J. T. Arlidge, M.A.
Northamptonshire Natural History Society—C. A. Markham, F.R. Met. Soc.
Perthshire Society of Natural Science—R. Brown, R.N.
Royal Scottish Geographical Society—H. R. Mill, D.Sc.
Warwickshire Naturalists' and Archæologists' Field Club—W. Andrews.
Woodhope Naturalists' Field Club—Rev. J. O. Bevan, M.A.
Yorkshire Geological and Polytechnic Society—J. W. Davis, F.G.S.
Yorkshire Naturalists' Union—Rev. E. P. Knubley, M.A.

FOREIGNERS.

Bonghi, His Excellency R., Rome
Cora, Prof. Guido, 74, Corso Vittorio Emanuele, Turin
Fittica, F., Marburg; A. Carse, Granville Road
Foote, A. E.. Philadelphia
Gilson, Prof., Louvain; St. Dominic's Priory
Giglioli, H. G., 19, Via Romana, Firenze
Hantken, Dr. Max von, Budapesth
Ivanoff, N., North Terrace, Alexandra Square, London, S.W.
Kund, Lieut. R., German African Society, Berlin; J. C. Stevenson, M.P., South Shields
Kollmann, Prof., Basle
Lunge, Dr Georg, Zurich; J. Heslop, Rye Hill
Packard, Prof. A. S., Brown University, Providence, Rhode Island, U.S.A.; Dr Norman, Burnmoor Rectory, Fence Houses.

Prekett, Thomas E. Maysville, Mason County, Kentucky, U.S.A.
Riley, Dr C. V., Washington, U.S.A.
Richards, Prof. T. W., Ph.D., care of Baring Bros., Bishopsgate Street, London.
Schering, Prof. E., Gottingen; Dr Merz, The Quarries, Clifton Road
Solms, Vicomte, Strasburg
Tchihatchef, Pierre de, Florence
Wiedersheim, Prof. R., Freiburg

BANQUET AT JESMOND DENE.

At night, Lord Armstrong entertained the leading members of the British Association to dinner in the Banqueting Hall, Jesmond. Lord Armstrong presided, and was supported by Professor W. H. Flower (President of the Association), Sir John Lubbock, M.P., Sir Wm. Thomson, Sir Douglas Galton, the Mayor of Newcastle (Mr. Thos. Richardson), the Lord Bishop of Newcastle (Dr. Wilberforce), Sir Frederick J. Bramwell (ex-President of the association), Sir Frederick Abel, Sir John Hay, Professor Cayley, the Right Hon. John Morley, M.P., and Sir Lowthian Bell. Invitations were also issued to the following, most of whom were present:—Capt. Noble, C.B., Sir John Adye, Mr. Rendel, Sir H. Thuillier, Mr. G. Romanes, Sir F. Galton, Mr Godfrey Smith, Prof. Bedson, Col. A. Cunningham, Dr. McIntosh, Col. Watson, Mr. Batalha Reis, Sir T. Buxton, Sheriff of Newcastle (Mr. W. Suttou), Canon Franklin, Mr. J. S. Swan, Mr. P. J. Messent, Sir W. Turner, Mr. M. Gladstone, Prof. Max D. Hautken, Prof. Garnett, Prof. Copeland, Dr. A. M. Marshall, Major-General Webber, Professor Carleton Williams, Mr. W. D. Stephens, Governor Moloney, Prince Bonghi, Sir Erasmus Ommaney, Dr. Nansen, Captain Abney, Mr. F. Godman, Mr. G. A. Fenwick, Mr. Benjamin Baker, Mr. J. W. Pease, Dr. Schunk, Dr. Blackie, Mr. F. Hawksley, Dr. Pole. Mr. Howard Fox, Lord Maclaren, Sir Joseph W. Pease, Mr. H. H. Howorth, M.P., Sir R. Biddulph, Professor Geikie, Mr. R. G. Hoare, Rev. Dr. J. C. Bruce, Mr. A. G. Vernon Harcourt (general secretary), Professor Hull, Mr. Chas. Barry, Professor Lebour, Mr. F. Morley, Ald. Milvain, Dr. Philipson, Professor Edgeworth, Sir Frederick de Winton, Canon Tristram, Dr. Thomas Hodgkin, Col. Potter, C.B., Professor Fream, Mr. W. Watson Armstrong, Mr. A. S. Flower, Professor S. Thompson, Rev. J. Buckle, Professor Mial, Professor Oliver, Sir G. Baden Powell, Sir Henry Acland, Sir R. Playfair, Canon Lloyd, Sir George Bowen, Mr. J. C. Stevenson, M.P., Professor Roberts Austen, Mr. A. Packard, Mr. R. T. Glazebrook, Mr. S. S. Flower, Alderman Barkas, Professor Maclead, Professor Uuwin, Dr. Perkin, Professor Heath, Professor Papp. Professor Newton, Mr. W. Nichol, Professor Tilden, Mr. W. Whitaker, Mr. Beddard, Mr. W. E. Hoyle, Mr. R. Jones, Mr. D. H. Nagel, Professor Perry, Mr. H. Thompson, Professor O. Reynolds, Mr. C. Bailey, Mr. H. Bonney, Professor Dixon, Professor Ewing, Dr. Page, Professor M. Ward, Mr. Macinder, Mr. E. W. Buckle, Professor F. O. Bower, Mr. J. T. Dunn, Mr. F. B. Fairley, Prof. Richards, Mr. W. Watts, Mr. J. F. Marr, Mr. R. E. Baynes, Prof. Fitzgerald, Mr. J. S. Kettle, Mr. W. B. Marshall, Prof. Rucker, Mr. H. B. Woodward, Mr. S. J. Harmer, Mr. S. Brown, Mr. G. Griffiths, Prof. Lodge, Dr. R. Monson, Mr. E. Rigg, Dr. H. Woodward, Mr. A. Gobert, Mr. H. B. Brady, Mr. F. Goddard, Prof. Heaton, Mr. L. T. Price, Dr. J. W. Russell, Mr. A. Scott, Mr. T. H. Elliott, Mr. J. J. Gurney, Prof. Hicks, Mr. H. Pease, Mr. J. M. Redmayne. Prof. Swithells, Mr. W. Cochrane. Mr. A. Aitchison (secretary), Mr. J. H. Armstrong, Prof. Liveing, Dr. Rutherford, Mr. W. N. Shaw, Mr. C. W. Cooke, Prof. Armstrong, Prof. W. Barrett, Mr. A. Lodge, Mr. R. N. Redmayne, Mr. H. N. Sulivan, Prof. Clowes, Dr. Gibson, Prof. Haddon. Mr. F. W. Rich, Prof. Stroud, Mr. L. L. Smith, Mr. J, G. Benson, Dr. Shand, Mr. E. J. Garwood, Mr. W. Garson, Mr. J. Pattinson, Mr. H. Shaw, Mr. W. Topley, and Mr. C. W. Bloxham. A large number of ladies watched the proceedings from the organ loft. The banquet was provided by Messrs. Ferguson and Forrester, of Glasgow.

At the conclusion of the dinner, the noble chairman gave the toast of "The Queen." He said the virtues of the Queen were so universally recognised that it was unnecessary for him to recapitulate them. It was sufficient to say that unquestionably she was the best sovereign of Europe, and that she reigned in the hearts of her people. (Loud cheers.)

The toast was loyally drunk.

The CHAIRMAN then said: The next toast I have to propose is the health of the Prince and Princess of Wales and the other members of the Royal family. All the members of our Royal family are ever ready to perform public duties, and by so doing they have earned well-deserved popularity. (Cheers.) We may take this opportunity of congratulating the Princess Louise of Wales upon having made a marriage pleasing to the nation—(cheers)—and also the whole Royal family upon their relief from this acrimonious discussion in Parliament upon the subject of the settlements to the Royal family. (Cheers.)

The toast was enthusiastically drunk.

The CHAIRMAN then said: The next toast is one which everyone present should consider as in some degree personal to himself. It is success to the British Association and the health of our president, a man who has risen to great distinction in science after passing through the perils of war in the Crimea. (Cheers.) It is, perhaps, not generally known to all present that Professor Flower was present in all the great battles of the Crimea in a life-saving capacity, and we may therefore well be proud of him as a Crimean hero as well as a man of science. (Cheers.) This is the third meeting of the British Association in this town, and I think it must be felt that the inhabitants of the city have on all three occasions evinced their desire, as well as their ability, to render the meeting a success. (Cheers.) Nothing could be more brilliant than the success of the first meeting held in this city, and if we may judge from the touchstone of receipts, the second meeting, at which I had the honour of being president—(cheers)—was equally successful. In fact, both these meetings, up to the date on which they were held, were the best meetings that have been held, and they have never since been excelled in one single instance. (Cheers.) It is perhaps too soon to pronounce upon the success of the present meeting, but this much is certain, that it will not be a failure, and we hope it will be a great success. The fact is that this city has many attractions for a gathering of this kind. There is a great affinity between smoke and science—(laughter)—and as we have plenty of smoke we naturally have plenty of science. (Laughter and cheers.) In addition to this we have many great factories and many noble institutions, and, notwithstanding our smokiness, we have a great natural beauty surrounding our city—(cheers)—and above all, we have a busy, enterprising population ready to give a hearty and a hospitable welcome to the British Association. (Cheers). I, therefore, call upon you to drink the toast which I have just announced; and although we may be considered as drinking our own health, yet I think we may indulge in three cheers on the occasion.

The toast was then drunk amid enthusiastic cheers.

Professor FLOWER, president of the association, responded. He said: Lord Armstrong and gentlemen, I think I must also say ladies, as I see we are not left without ladies. In fact, ladies are here, not as in the House of Commons behind a grating, but are gracing the room by their presence. I feel that it is a very great honour indeed to be the mouthpiece of such an institution as the British Association on an occasion like this. It is an honour that I never should have aspired to. Until a year or two ago I thought I never should attain it. It is one I have attained to more from the kindness of my friends than any merit of my own. When I look round I see who have occupied this chair. I see five very distinguished ex-presidents sitting at this table, and I also see more who are going to occupy the chair. I see present—I must not call him president elect yet, but I believe president designate is the term. They go through three phases, and I hope he will be president elect this year, and next year will be president. When I see so many future presidents more fit to occupy the chair than I am. It is a position which makes me think—it is a position that no man of science can attain to, although very humble in his own merits, without being proud to be placed in it. I am not going to weary you now, as we have to adjourn presently to the entertainment provided by the Mayor and Corporation. I only wish to say a few words about the social aspect of the association. Perhaps I said enough last night upon the scientific aspect of the association, and I merely wish to mention the great advantage these meetings are from a social aspect. The banquet at which we have been entertained to-night is a most splendid illustration of the valuable aspect of the meetings. (Cheers.) Lord Armstrong has brought together to-day a great many in this room who are very glad and very pleased to meet each other on common ground, and we owe very much to his generous hospitality in assembling us here in the room that he has built himself, situated in this splendid public garden, which he has given to the town. (Cheers.) One of the greatest possible benefactions that any man could confer on his fellow citizens, I think, is to confer on a city like Newcastle such a public recreation ground as this beautiful valley where we now are. (Cheers.) I think next to building and endowing a museum—(laughter)—it is one of the best things he could do. In the name of the Association, and briefly, I beg to thank Lord Armstrong for his hospitality, which has conduced very much, if not in scientific blessings, to the social aspects of this gathering. In fact, science without a rest, at a British Association meeting, would not be, I think, nearly so valuable. I also wish to include in my thanks the extreme kindness, cordiality, and grace with which Lady Armstrong has welcomed us to her house, and the hospitality she is also going to extend to many of us at her other place at Cragside, and I wish to include Lady Armstrong in the thanks we all ought to offer to his lordship for their kindness and hospitality, which has done a great deal to add to the pleasure and success of this meeting. (Cheers.)

The CHAIRMAN, again rising, said : Our next toast is the learned societies of Great Britain. Any one who casts his eye down the list of visitors to this meeting of the association will see long strings of letters affixed to almost every name, indicating that he belongs to some scientific society—some learned society. Therefore, we are all in sympathy with the learned societies, and I am sure you will all join in drinking success to them with great heartiness. Chief amongst them, of course, is the Royal Society, of which I have myself been a fellow for now over 40 years—(cheers)—and in the prosperity of which I feel the greatest interest. I fully expected we should have had present this evening Dr. John Evans, who is the able and energetic treasurer of the Royal Society, but, unfortunately, he has been prevented from coming. But we have many very distinguished fellows of the Royal Society present, and prominent amongst them is Sir William Thomson whom I am glad to see on this occasion, and I will invite him to return thanks in acknowledgment of this toast. (Cheers.)

Sir WM. THOMSON, in responding, said he was sorry Dr. Evans was not present to return thanks for that toast for the Royal Society and with it for the other scientific societies of the United Kingdom. He felt honoured in being called upon to return thanks for the toast. As President of the Royal Society of Edinburgh, he was very glad indeed to express their gratitude for what the noble chairman had said, and for the consideration that he had given to the claims of the learned societies of the United Kingdom in respect of the advancement of science. The British Association was itself one of the most remarkable offshoots of the learned societies of the world. (Cheers.) The British Association was an institution altogether unique. It originated about 58 years ago for a purpose that had previously been contemplated. How splendidly successful the plan of the originators of the British Association had been was manifested by the three meetings of the Association which had been held in Newcastle. (Cheers.) It was not only the meetings at Newcastle, however, which had shown the success and demonstrated the wisdom of the founders of the British Association. He believed every meeting of the British Association had been a success. (Hear, hear.) It was impossible that every meeting should be better than every other, but it was not impossible that every meeting should be excellent and that every meeting should be a success, and he thought they might say that of every meeting during the fifty-eight years. (Cheers.) The different learned societies whom he had the honour to speak for did a great work for science, but it was a work which was supplemented in a most admirable manner by the British Association, and he was quite sure that all those who attended the meetings of their own societies and took a part in the proceedings must feel that in a certain sense the British Association was a combination of all, and brought together the energies and the interests that have been devoted to work in different parts of the country—brought them together in one place or another, and at the meetings of the British Association they did not meet merely fellows of the Royal Society of Edinburgh, or merely members of the Royal Irish Academy, or the Royal Society of London, but they met all who were interested in one common object. And in that respect the meetings of the British Association had been uniformly, from the beginning to the end, stimulating, and were adapted above all things for carrying out the object of the British Association, and that was the advancement of science. (Cheers.) It was singularly appropriate to bring the British Association to Newcastle, where they saw the application of science all round, where they saw the most magnificent application of scientific principles and experience, where they saw the results of learning from what was observed by practical men, who turned science to useful purposes that would otherwise never have been discovered in the laboratory or works of persons cultivating science for its own sake. He thought, when they saw the British Association bringing together the different workers on such different lines, and giving the fruits of their labours in that admirable manner, that it had been a most successful institution. (Cheers.) In the name of the scientific associations of the United Kingdom, he thanked his lordship for the toast he had proposed, and the gathering for the way in which it had been received. (Cheers.)

Mr. JOHN MORLEY, M.P., was received with hearty cheers. He said : The toast which it is my privilege to propose to you is one which will need very few sentences from me to commend it to your attention. Wishing to be in keeping with the occasion, I have during dinner been turning over a few philosophic generalities connecting local self-government with science. (Laughter and cheers.) I believe I shall best consult your wishes by leaving those philosophic generalities for some future and more favourable time. (Hear, hear.) The Corporation of Newcastle is one of the most ancient in this realm. I am not sure that there is any other, excepting the great Corporation of the City of London, which has charters so old as they have in the city of Newcastle. And I am glad to think—and you will be glad to know—that this local and municipal spirit which made Newcastle distinguished centuries ago, still animates the descendants of those who administered its affairs. (Cheers.) You had, gentlemen, last night, in the speech of the Mayor of Newcastle, a specimen of the kind of men whom local self-government brings forward to a prominent part in local affairs. (Cheers.) And I agree with an old friend of mine who on going away from the meeting last night said "That is the best specimen of a mayor that I have ever seen." (Cheers.) I believe that the Corporation of Newcastle does what I wish all other Corporations in the country would do ; it gathers to itself and it embraces citizens of good repute, substantial and sound position, and of high cultivation and intelligence. And the more men of that stamp—the more men of the stamp of the present Mayor of the city of Newcastle engaged in local affairs, the better it will ultimately be for us all. (Cheers.) The Corporation of Newcastle, I believe, uses for good every purpose to which what is called the wisdom of Parliament allows it to apply itself. The parks in Newcastle, the Library in Newcastle, the baths and wash-houses in Newcastle are all modols of what municipal government can do. (Cheers.) But, gentlemen, there is one point to which I hope the Mayor will allow me to refer, in which I think Newcastle, so far from being in advance of other Corporations, is seriously behind them. (Hear, hear.) I mean this, that in Newcastle we have no great Town Hall, no great meeting place, which is at all worthy of an important municipality, and which at all meets the various desires of its citizens and those who come among us. (Cheers.) It is too late to labour that subject, but I believe I have the Mayor of Newcastle with me upon that point. I believe that he and his colleagues on the council regret exceedingly that we have no better accommodation to offer you than the atmosphere which prevailed last night. (Laughter.) I am sure all of you who are strangers to Newcastle will agree with me in humbly and respectfully commending to the Council, and to the Mayor, as head of it, the expediency of doing for Newcastle what has been done for places like Manchester and Birmingham—of erecting (call them palaces if you like) a building where citizens may meet to discuss the subjects of civil contention, where music may be heard with some chance of favourable circumstances for the audience and the performers, and where the British Association may find a worthy place in which to listen to such an address as we heard last night. (Cheers.) My lord and gentlemen, I will not say any more, except that I count myself very fortunate in being able to commend this toast to you in connexion with a gentleman who, in powers of oratory, in powers of business, and I think in good taste and good feeling in the circumstances in which he finds himself, discharges the duties of his high and honourable office, so well, as the present Mayor of Newcastle. (Cheers.)

The **Mayor**, who was received with loud cheers, said: I am exceedingly obliged to you for the cordiality with which you have received this toast. I can assure you that the Corporation of Newcastle receives the British Association with the greatest cordiality. (Hear, hear.) It is a pleasure to us to welcome to this city an association which has done so much to foster the spirit of investigation and inquiry, and thereby extend the circle of human knowledge; and at the same time to welcome to our midst such a large number of influential men—men of renown in the scientific world. Now I need not say that Newcastle depends to a large extent for its prosperity upon the application of science—upon applied science in various directions and in the multifarious pursuits to which it is applied. Upon applied science depends the very subsistence of thousands of our population, involving as its does the circulation of wealth and the consequent prosperity of the district. I need only refer to the Elswick Works, of which of our noble host is the founder, as an illustration of this truth; and on either side of the river, for miles down, you will find yards and factories in which thousands of skilled men are employed in productions which unquestionably add to the weath of the district and probably add also to the prosperity of the country. (Cheers.) This city has many reasons to appreciate the advancement of science. It is rich in its scientific prestige, and let me add in the heritage of scientific men. (Cheers.) My right hon. friend Mr. Morley has complimented the Corporation of Newcastle, and at the same time has referred to our defects. I admit the soft impeachment. I admit that in tho Town Hall we have shown appreciation neither of art nor of science. But I will guarantee to you that tho next time you arrive here that reproach will be removed. (Cheers.) Allow me to express the hope that you will all, individually and collectively, enjoy your visit here, and that it will be of great service to the country and to the world. Throughout the vast area of your investigation and study, from Orion and the Pleiades to that interesting but very delicate subject of ladies' corsets—(laughtor)—from tho infinitely great to that which encircles the infinitely little—(renewed laughter)—I hope you will keep in view thoso great utilitarian ideas which, after all, are best suited to this practical age. (Cheers.)

Sir **Frederick J. Abel** proposed "The Foreign Visitors." Ho said that among the privileges which the British Association enjoyed at their annual gatherings, one of the greatest was that of welcoming among thom their brethren from foreign countries—(hear, hear)—their fellow-workers, with whom they had so much in common. From year to year they examined with curiosity the list that was placed before them of men who had thought it worth their while to travel long distances to come to them, to be received, as they knew, with cordiality—with affection, he might say, as fellow-workers in the various branches of education. (Applause.) The numbers variod in different years, and their list on the present occasion was not so numerous as it sometimes was. And yet they had representatives of many countries. Foremost among these he must refer to many of their visitors from the other side of the pond—(a laugh)—and he might mention in passing that they owed a deep debt of gratitude to and welcomed friends of whom they, and especially the British Association, had the happiest recollections—(applause)—and who, when it was their pleasure to visit a distant part of her Majesty's dominions, received them so kindly and so cordially that they would never forget it. (Applause.) They had representatives from Germany and from Hungary, from France and from Italy, from Switzerland, from Russia, from Denmark, and from Norway. (Cheers.) And would their Norwegian representative (Dr. Nansen) be so good as to allow him to couple his name with the toast? (Cheers.) They must heartily welcome a man who exhibited such endurance in the exploration of Greenland, who had added so much to the knowledge of a most interesting country—to a man who showed not merely physical fortitude, but that intelligence which was so indispensable to an explorer—Dr. Nansen. (Cheers.) Young as he was as an exploror, he had before him a glorious career. With these few words, he asked them to drink cordially the health of their foreign visitors on this occasion, and to couple with the toast the name of Dr. Nansen.

The company, having honoured the toast, joined in singing "He's a jolly good fellow."

Dr. **Nansen** was received with enthusiastic cheering. He said he could not tell them how much he felt honoured by the toast for which he had been called upon to return thanks. He was, he believed, the youngest of the visitors from abroad, and still he was called upon to return thanks for the toast of the foreign visitors, and he was not able to return thanks as it ought to be done. He was sure that all foreigners agreed that England and the English nation were hospitable as no other nation in the world. He did not know whether he thought this because Norwegians were kin to the English—(langhter)—but at all events that was his feeling; and he hoped that other nations that were not so nearly related to England thought the same. (Hear, hear.) Ho wished to return thanks to their host. He need not tell Lord Armstrong that his name was known in Norway. Certainly, they knew him in connexion with war, but, still, they knew the name of Lord Armstrong. They had heard of the guns of Lord Armstrong since they were born. (Laughter.) He thought the world would be better than it was if every nation could have such a society in its midst as tho British Association. Ho would ask them to drink to the prosperity of the British nation and of the British Association, The English nation was no doubt the greatest nation in Europe—in the world. He hoped the British Association would have as good a future as its past had been—(hear, hear)—and that many foreign visitors, as well as English men of scienco, might gather togother and contribute to scienco as much as that society had done before, and he was sure that scionco would bring as much to the human race as it could do. (Applause.)

Sir **Frederick Bramwell** (ex-president) said, I think the position of a speaker who finds himself low down in the list is always a very bad one. He may come with certain prepared ideas, and he finds that each man as he speaks forestalls him in certain of them, till he leaves him nothing wherewith to speak in person. (Laughter.) But fortunately for me, I am not on the toast list at all, and therefore I don't come within the category. Much more fortunately for me, my toast is such that no man can do me injustice, or can rob me of that which is my due. I will ask you to fill your glasses, bumpers, and drink to the health of our host, Lord Armstrong. (Cheers.) And I will say an apparently discourteous thing, which is that I wish he was not here. If he were not here I could briefly, but, I think, forcibly bring before you that which no doubt must be in most of your minds—the various claims that he has upon the consideration of the members of the British Association. He himself has told you that this is the third meeting of the Association in Newcastle which he has attended—one as a comparatively young man, again when not an old one, as president, now in a mature age, again, here as a host, and as one of the most honoured members of the Association. (Cheers.) I think we must for a moment pause and consider what this man on my right hand has done in the 51 years that have elapsed since the meeting which he first attended. Remember, beginning life in a totally different profession from that of a scientist or an engineer, he first brought to work and to bear in this city of Newcastle an establishment unparalleled, I believe, throughout the world. (Cheers.) By his talent and industry he has brought here an arsenal second to none in the kingdom, without subsidies by Government of any kind or description—a private enterprise, due to his ability in the outset, due to that ability afterwards aided by the men whom his own ability has brought about him. An able man is a source of ability in others, and attracts to himself those who can best help him in the work that he has originated. (Hear, hear.) I am quite sure that this country possesses in the establishment at Elswick a line of defence—for I can call it nothing else—which is of the greatest possible value to this kingdom. (Applause.) And it is well to know that, should the day of trouble ever come, an establishment is here for the use of the nation, costing us not a farthing, enriching thousands of working men in this city and in other places, the origin of a man who devoted himself to that pursuit because he could not help it. It was in him: it was not that to which he was brought up, but it was that to which he felt himself drawn, and he could not avoid it. Therefore you will say that to that extent less credit is due to him. (Laughter.) However, I don't think we shall be evil enough to discount his merits on that ground. Remember, we have only spoken of the side of war. I have said it before, and I desire to repeat it, we have had before us to-day in Section G papers dealing with the transmission of power. Now, whatever may be the final result of this transmission,—whether water under high pressure, as originated by the man who is here to-night, whether electricity, air, the exhaustion of air, or whatever it may be, we cannot forget this fact, that it is to Lord Armstrong that we owe the real practical bringing into work the distribution of power from a central source, and I say that that distribution of power from a central source has operations far wider and more important than the mere provision of mechanical force at a distance. It has enabled works to be undertaken which otherwise, so far as we know, could not have been undertaken at all. It has also rendered it impossible that a man can earn a living by mere brute labour—the labour of a turnspit or of a squirrel in a cage. He must now have brains as well as muscles, or else the provision of power hydraulically from a central source comes in and prevents him from getting the living he formerly could get without the exercise of intelligence. And I say, hard as such a thing may be in the change, it is in the end for the advancement of the human race that there should be introduced the means of depriving a man from earning his living by acting as a mere muscular machine, and not as a human being. (Hear, hear.) We all should remember that, long before Lord Armstrong took to the defence of the country, he had originated and brought into perfection that marvellous application of the distribution of power hydraulically with which his name ought ever to be associated. It is applied in these days in a manner which even Lord Armstrong could not have thought of when he introduced it. Remember that now, by the mere pulling of a lever, dock gates of eighty feet span are opened with the greatest ease; and in a few minutes swing bridges—the low level bridge on the Tyne—are brought from their position and made parallel with the stream—bridges weighing hundreds of tons. A great ship is put into a pontoon and raised vertically without the aid of locks, all by the distribution of this hydraulic power. Again, now that we have to deal with enormous masses of steel, instead of injuring the metal by the application of blows from the surface — which make the hammer as large as you will, are but surface blows. When we have to deal with the masses of steel that now are used in artillery and in steamships, we, by this very hydraulic power, forge these masses by pressure and not by percussion, with the greatest benefit in the results. (Applause.) I will not detain you longer. As I say, I labour under the difficulty of having Lord Armstrong present. But I am sure of this, that whatever my inadequacy of speech may be, you will most heartily respond to the desire that we should drink to the health and to the prosperity of our host and most eminent man of science and of practice—Lord Armstrong. (Loud cheers.)

Lord ARMSTRONG, who was received with loud cheers, said: I am exceedingly obliged to you for the kind and enthusiastic manner in which you have received this toast; and I must heartily thank Sir Frederick Bramwell for the flattering observations which he has made, and which I feel go very far beyond my deserts. I feel quite unable to respond to observations of that character; and can do nothing more than thank you most sincerely, and to express to you the very great pleasure it is to me to see you here this evening. It is quite true this is the third meeting of the British Association in Newcastle on which I have had the pleasure of showing hospitality to persons who have attended it, and I think very few persons living can say the same thing. It would be a miracle if I were to receive you here again on a similar occasion; and as I am not a believer in modern miracles, I am quite sure it will not happen. But I hope and believe there are many, however, present who will at the fourth meeting of the British Association in Newcastle be hospitably entertained in this hall. We have now to adjourn to the entertainment at the Museum, and it will only postpone our reception there if I detain you with any further observations. I merely repeat therefore my most earnest and hearty thanks to you for the honour you have done me in coming here this evening. (Cheers.)

The proceedings then terminated.

CONVERSAZIONE AT THE MUSEUM.

In connexion with the visit of the British Association to the city, the Mayor and Corporation of Newcastle last night held a conversazione at the Natural History Museum, Barras Bridge, where a very large and fashionable gathering of guests met Professor Flower and the members of the British Association. Most elaborate arrangements had been made for the occasion. The immediate precincts of the Museum and the approaches to the noble structure had undergone complete transformation at the hands of the carpenter, the decorator, and the florist. Alongside the two ordinary entrances to the building in the North Road an awning, illuminated by electricity, had been erected. Electricity, supplied by cables from the College of Physical Science, served to make the external surroundings, one almost perfect light, and rendered the spectacle on the skirts of the thoroughfare one of great brilliancy. Soon after seven a continuous string of carriages drew up at the entrances, and in this way matters continued until after eight o'clock. From the roadway two distinct, covered-in, and carpeted avenues led up to the space in front of the Museum entrance. This space was utilised as a depository for cloaks, hats, sticks, &c. From here three distinct carpeted avenues, with evergreens on each side, led to the hall of the building where the guests as they arrived were received by the Sheriff and Sheriff's lady (Mr. and Mrs. W. Sutton), and the Mayoress (Mrs. Richardson), the Mayor being unable to be present until about nine o'clock, having to be at the banquet at Jesmond Dene. Inside the building the guests visited the different rooms, some giving their attention to the drawings, others to the collection of birds, and so on. Another section seated themselves in the different rooms, and engaged in conversation or in listening to the selections of music rendered in first-class style by Mr. J. H. Amers's band. It was indeed a splendid spectacle. The many-coloured and beautiful dresses of the ladies formed a pleasing contrast to the sombre attire of the gentlemen, and, in some cases, the even more sombre surroundings. Such a gathering of the *elite* of Newcastle and the surrounding district has not been witnessed in Newcastle for many a year. If anything, the building, which it must be stated is admirably adapted for such a purpose, was much too crowded, and it was a matter of the utmost difficulty to move from one room to another. Considerable interest centred in the Rev. Dr. Bruce's views of the Roman Wall and Gibsone's drawings of conches; and particularly in a lecture on "The Science of Animal Locomotion in relation to its Design in Art," illustrated with projections, by Mr. E. Maybridge, of the University of Pennsylvania. This lecture was delivered in the west corridor before a large number of guests. Mr. Maybridge has obtained a considerable reputation in the matter indicated, and last evening his remarks were listened to with great attention, and his illustrations witnessed with interest. He exhibited, with the aid of an apparatus known as the zoopraxiscope, a large number of photographs of the successive movements of animals in motion. He showed the horse in the act of walking, ambling, trotting, and galloping. The decorative work in the building was executed by Messrs. Carnegie and Co., Northumberland Street; the floral decorations were by Mr. W. J. Watson; whilst the refreshments were supplied by Mr. Crosby, Grainger Street.

THE THIRD DAY'S PROCEEDINGS.

FRIDAY, SEPTEMBER 13, 1889.

SECTION A.—MATHEMATICAL AND PHYSICAL SCIENCE.

THE EFFECT OF LIGHT ON PHOTOGRAPHS.

The PRESIDENT read a paper on "Intensity of Light Productive of Density of Deposit in a Photograph." He said that, in his address to Section A, he had already alluded to the fact that the transparency of deposit caused by development in a photograph could be expressed as a foundation of the intensity of light acting, or the time of exposure, which was the same thing, and he had said that it could be brought into the form of the law of error. He would briefly explain how this was done. In a Spurge's sensitometer (which was the most useful instrument he was acquainted with for accurate measurement) different parts of the same plate were exposed to different intensities of light, the intensity being regulated by the size of the apertures through which the light was admitted to the plate. As a matter of fact, every third aperture doubled the light admitted, and as there were 30 apertures, it would be seen that the variation of light was very considerable. When experimenting with this instrument, and after carefully measuring the transparency of deposit, he found that the error followed the law of frequency as given in the ordinary law of error. The transparency of deposit was a very different matter from the amount of deposit. They might take a certain number of particles of a substance and distribute them haphazard over a given transparent area, and they would get the transparency area diminished by a certain amount, but it by no means followed that if double the number of particles were distributed over an equal and similar area, the transparency area left would be diminished by double the amount. It became necessary for an investigation of the theory to ascertain whether the deposit made by development was proportional to the intensity of light acting. The experiments which succeeded showed that the amount of deposit was according to the light acting. Having described in detail the nature of the experiments, he said the results made it pretty certain that the amount of silver deposited in development was proportional to the intensity of light acting.

Sir W. THOMSON asked whether the methods could be used with any advantage at all as a means of measuring the intensity of light on different wave lengths. They understood the difficulty of getting very accurate measurements.

Capt. ABNEY had applied the methods to measure the intensities of light, with very satisfactory results. It was a very accurate method when they had proper instruments for measuring the deposit. That was the real secret of the thing.

Having replied to other questions, Capt. Abney was thanked for his paper.

PIN-HOLE PHOTOGRAPHY.

Lord RAYLEIGH read a short paper on "Pin-hole Photography," and prefaced his remarks by stating that the first camera ever made was a pin-hole camera, a camera in which an image was formed with a simple aperture without the aid of a lens. In most cases the use of a lens was a vast improvement; but, nevertheless, it was of considerable interest from a scientific, if not a practical point of view, to examine what could be done in the way of formation of images without the use of the ordinary appliance of the lens. It was shown in the *Philosophical Magazine* for 1880, that a simple aperture was as effective as the best possible lens in forming an image, provided only that the focal length was sufficiently great. The aperture might be made so small that the use of a lens would give no advantage. If the focal length was such as was usually afforded by a camera, the admissible aperture, being very much less than that of the pupil of the eye, was insufficient for reasonable focal definition. In some recent experiments the focal length was about nine feet, and the aperture a sixteenth of an inch. The specimens exhibited were taken upon gelatine plates, and represented a weather-cock seen against the sky. The amount of detail was not materially less than that observable by direct vision in the case of ordinary eyes. As the focal length increased, the brightness of the image in a properly proportional pin-hole camera diminished. Modern plates were so sensitive that there would be no difficulty in working with an aperture equal to that of the pupil, other than that incurred in providing a focal length of 66 feet, with the necessary exclusion of foreign light.

The PRESIDENT spoke of the utility of taking photographs with pin-holes, and instanced cases where this had been done by photographic parties who had gone into the country and forgotten to take their lens with them.

The customary vote of thanks was accorded to the reader of the paper.

BOSCOVITCH'S THEORY.

Prof. Sir W. THOMSON delivered a long and able address on Boscovitch's theory that matter consisted of atoms which were mathematical points endowed with the property of inertia, attraction, and repulsion.—A long discussion of a theoretical nature followed, after which Sir William was thanked for his address.

ELECTRIC OSCILLATION.

Professor O. J. LODGE read a paper on "The Determination of 'v' by means of Electric Oscillations." The paper was supplemented by remarks from Mr. R. T. Glazebrook, F.R.S., one of the secretaries of the section.

IMPROVED MAGNETIC INSTRUMENTS.

Professor A. W. RUCKER, F.R.S., delivered a short address on "The Instruments used in the recent Magnetic Survey of France." He said a very good magnetic survey of France had lately been completed by MM. Moureaux and Mascart. They had made observations at about seventy stations in different parts of France. The instruments they used were a magnetometer and a dipcircle. The instruments were in many respects more convenient than those at Kew used in England. Their cost was £140. It would be, he thought, interesting to make observations with the instruments exhibited and compare them with those at Kew. It would be very advantageous if this could be done.

Professor W. G. ADAMS remarked that it was very desirable that there should be some smaller instruments than the Kew instruments to do the work.

MAGNETISATION OF IRON.

Professor W. T. BARRETT read the report of the committee on the magnetisation of iron. The committee reported that at the meeting of the British Association held at Bradford, in 1873, a paper was read on certain remarkable molecular changes occurring in iron wire at a low red heat. In this paper the phenomena known as the recalesence of iron was first published, it having been observed by the author early in September, 1883. At the suggestion of the late Professor Balfour Stewart, a small committee was appointed to investigate and report on recalesence and other molecular phenomena. This committee had some meetings, and a good deal of unpublished experimental work was done by the secretary (Professor Barrett), but no quite satisfactory explanation of the main point, the phenomenon of recalesence, was arrived at. The death of Professor Maxwell and Professor Balfour Stewart left the matter in abeyance, and the committee lapsed before a report was presented. The committee, however, had since been re-appointed. It was proposed on the present occasion to present a formal interim report, and reserve till next year the full report of the committee. The report continued :—So much work has of late been done on the general subject of the molecular phenomena attending magnetisation that it would now be beyond the scope of the committee to adequately report on the whole matter. We propose, therefore, in the first instance, to confine our report to those phenomena accompanying the so-called critical temperature of iron, that point in, or near which, the magnetic state is lost in heating and regained on cooling. The report then quoted *in extenso* from a paper read at the British Association in Bradford in 1873, and continued :—When we remember that the mechanical, electrical, and thermal properties of iron and steel are of the utmost practical importance, and that all these properties appear to undergo a remarkable change on this critical temperature, the need of a searching investigation on this question is obvious. Moreover, the interest is no less from a theoretical point of view in connexion with theories as to the molecular structure of magnetised iron and steel. Recalesence being feeble in soft iron, more marked in hard, and most in steel, it was conjectured that the phenomenon might be due to an action depending on the presence of carbon in iron, creating an effect analogous to that observed when water or supersaturated solutions are cooled below the solidifying point, a slight disturbance, therefore, producing a sort of explosion, and active solidification occurring with a certain rise of temperature. Professor Robert Austin had drawn the writer's attention to the fact that lately M. Osmund, in France, has made recalesence a starting point of a new inquiry. Tracing the effects of carbon and other compounds on the point at which recalesence occurs or is destroyed by the alloy, he found that whitish pure iron does undergo a molecular change at a red heat, and carbon retains it positive as an important factor in delivering the point of recalesence in hard iron and steel. The general subject of recalesence might be more advantageously discussed in a separate paper which he proposed to lay before the section the following day.

The report was adopted.

Professor J. A. Ewing, F.R.S., read a paper on magnetic viscosity in iron, and after thanking him for so doing,

SECTION B.—CHEMICAL SCIENCE.

THE TEACHING OF CHEMISTRY.

The first business of the section was to receive the report of the Committee on Methods of Teaching Chemistry. The following is the chief feature of the report of the committee, which consisted of Professor H. E. Armstrong, Professor W. R. Dunstan (secretary), Dr. J. H. Gladstone, Mr. A. G. Vernon Harcourt,-Professor H. M'Leod, Professor Meldola, Mr. Pattison Muir, Sir Henry E. Roscoe, Dr. W. J. Russell (chairman), Mr. W. A. Shenstone, Professor Smithells, and Mr. Stallard, appointed for the purpose of inquiring into and reporting upon the present methods of teaching chemistry. In a report presented to the Bath meeting, the committee gave an account of the replies they had received to a letter addressed to the head masters of schools in which elementary chemistry is taught. In this letter the committee had asked for a report on the chemical teaching, and also for a statement as to the methods which had been found to render the teaching most effective as a mental training. In commenting on these replies the committee pointed out that the evidence which had been collected was conclusive in showing that much of the teaching of elementary chemistry is far from satisfactory, and needs to be considerably modified if it is to effect that valuable mental discipline which science teaching can afford. Since the last meeting the committee have been actively engaged in discussing the lines which a course of elementary instruction in chemistry should follow. The committee were the more inclined to offer suggestions of their own, since they had learnt from the replies made to their letter of last year, by teachers in many of our well-known schools, that not only is the necessity for the adoption of improved methods fully recognised, but that teachers are anxious to receive advice and assistance in introducing them. It cannot be too strongly insisted that elementary physical science should be taught from the first as a branch of mental education, and not mainly as useful knowledge. It is a subject, which when taught with this object in view, is capable of developing mental qualities that are not aroused, and indeed are frequently deadened, by the exclusive study of languages, history, and mathematics. In order that the study of physical science may effect this mental education, it is necessary that it should be employed to illustrate the scientific method of investigating nature, by means of observation, experiment, and reasoning with the aid of hypothesis; the learners should be put in the attitude of discoverers, and should themselves be made to perform many of the experiments. The suggestions of Dr. Armstrong for a course of construction included lessons on common and familiar objects, lessons in measurement, studies on the effect of heat, the problem stage, the quantitative stage, studies of the physical properties of gases in comparison with those of liquids and solids. Next followed a scheme for the teaching of chemistry in public elementary schools, drawn up by Professor Smithels. His conclusions include these :—That the teaching in elementary schools is unsatisfactory; that the teaching should be under the control of one educational department; that the present inspectorate is ill-adapted for the supervision and control of chemical teaching, and that special or additional inspectors, suitably qualified, should be appointed. A number of other conclusions were given. Finally the report said :—Very exaggerated notions exist, and are becoming more and more prevalent, as to what may be properly attempted so far as the teaching of chemistry in elementary schools is concerned. The public do not realise that in the countries where science is most cherished and applied most extensively and successfully to industry (*e.g.* Germany and Switzerland), the chemical and science teaching in the *elementary* schools is of the most simple and general character, and that the systematic teaching of science for technical purposes begins only in higher schools, polytechnics, and universities. This systematic teaching depends for its success no more on the previous training in science than on the previous training in arithmetic. It demands solely that the previous training shall not have given merely *information*, but that it shall have developed *intelligence*, that it shall have been rational and thorough, and have been administered by good teachers. In this country too much or too little is being attempted, and it is quite a common thing to find boys possessing a large amount of detailed "information" about chemistry, and a certain mechanical aptitude in chemical analysis, who are unable to do a sum in simple proportion or to write their own language correctly. The most that can be properly aimed at in teaching chemistry in elementary schools is the training of the faculties of observation and of orderly thinking, and the stimulation of the instinct of inquiry, which is the possession of every "uneducated" child. By restricting the teaching to common things and occurrences this can easily be done, and so an interest aroused both in the phenomena of nature and in those involved in industrial operations. In this way there will be created an interest in and appreciation of chemistry amongst the many and preparation made for the few who can proceed to the highest study of the subject, which alone is *directly* applicable to the advancement of industry.

Dr. Tilden recognised the great importance of the work, for if the committee succeeded in their aim, they would have done much to promote what was a great national need—that of the provision of what was called technical education. The key to the whole question, he thought, was that the most important thing to aim at was improved qualifications on the part of teachers, who should themselves be well qualified and able to impart. The reverse of this was often the case, the fault being largely that of the governing bodies and the head masters, who often did not regard physical science as occupying a serious place in their curriculum. They looked upon it often as a means of filling up spare time and as a recreation. And in the elementary schools the position was much the same. (Hear.)

Mr. V. Cornish remarked that if headmasters did not regard science teaching as serious, it was largely because they did not yet see that it was the imparting of the knowledge of useful facts. Until it was taught for its educational value they would not get the authorities to look on it seriously.

Mr. H. J. Mackinder, looking at the matter from its geographical aspect, remarked that it was easier to teach the elements of science than the elements of geography.

Professor Richards stated that in America the same battle was being fought on this subject.

Professor Smithels defended his proposal that geography and elementary science should be taught as one subject. He had come to that conclusion after much thought, and he was supported in it by the opinion of inspectors of schools. He believed that the amalgamation could be effected without prejudicing either subject, and if carried out, he thought there would be no crowding out of either subject.

Mr. C. R. Wright, as having been engaged in elementary schools, and now the headmaster of a higher grade school, agreed that geography and science should be combined; but he did not believe in the commendation of the peripatetic system of instruction.

Mr. G. Nicholson, London, pointed out the inadequacy of the numerical staff to teach science in one of the largest endowed schools. In it, in 1883, there were 40 pupils to one master; in 1888, there were 217 pupils to one teacher; and this year 230 pupils to the one master. He contrasted this with the great attention the classical studies received, and the large staff employed. The boys came in a deluge on the science master, but they went in units to the classical master. (Laughter.) An adequate staff of teachers was essential.

Dr. Gladstone believed in the peripatetic system as a temporary expedient. He thought the attention now given to it would induce managers of schools to pay more attention to natural science.

Professor Armstrong, in reply, expressed the general satisfaction of the committee with the general tone of the discussion. They saw in Newcastle extraordinary developments of industry, and they should ask why was science, so much needed, making such small progress in schools? And the science and art department knew well that it was no use putting forward requirements in advance of the teachers. If the teachers accepted such a scheme as that propounded, he believed the science and art department would also.

ALUMINIUM FROM CRYOLITE.

Professor P. P. Bedson read a paper on the "Manufacture of Aluminium from Cryolite." In it, having referred to the fact that at the last meeting of the British Association to Newcastle the manufacture of aluminium was carried on at Washington by Sir Lowthian Bell, but that shortly after the manufacture ceased to be a local one, but had now been recommenced this year, he proceeded to describe the methods of manufacturing aluminium. Coming to that of the manufacture from cryolite, he showed how the difficulties in the production from cryolite had been overcome. By means of diagrams he explained the method of manufacture at some length. By photographs he showed the operation of the introduction of the sodium, and the pouring off the slags with the residue of the aluminium. One of the notable features was the short time in which the decomposition of the cryolite by the sodium took place. By the process about 10lbs. of aluminium were produced from 40lbs. of sodium. He stated that to produce 1 part of aluminium 12 parts by weight of cryolite, 12 of common salt, 20 of coal, and 3 of sodium were needed; and he expressed his obligations to Professor Netto and the Alliance Aluminium Company for the opportunity of visiting the works at Wallsend. A series of samples of caustic soda, metallic sodium, &c., were shown.

In conveying the thanks of the meeting to Professor Bedson, Sir I. L. Bell, who had now resumed the chair, remarked that he still retained an interest in the manufacture of aluminium, and had been charmed with the simplicity of the process described.

CHILIAN MANGANESE.

A paper on Chilian manganese ore, by Mr. John Pattinson and Dr. H. S. Pattinson, followed. In it attention was drawn to the recent large growth in the demand for rich manganese ores, and that whilst they were imported from Spain, Portugal, and several other countries, out of about 85,000 tons imported last year, some 25,000 tons were brought from Chili. He gave three analyses of Chilian managose ores, and added that one of the special features was their freedom from phosphorus. The deposits in Chili were practically inexhaustible.

BARIUM SULPHATE IN WALES.

Professor Frank Clowes read a paper on Barium sulphate deposits in the waters of Durham coal-mines and in Nottingham sandstone. After describing the analysis of the sandstone to which he had drawn attention at a prior meeting of the association, he gave also analyses of deposits found in the pumping boxes at collieries near Durham and in this district. But in neither case was there proof of how the deposition had occurred, though various theories were suggested

ALLOYS OF ALUMINIUM.

A paper on "The Manufacture of the Alloys of Aluminium in the Electric Furnace" was read by Mr. J. H. Dagger, who described the method of production at some of the works in the United States and in Staffordshire. The following is an abstract of this paper:—Deville's method, modified in detail, is still the chief of the chemical processes for the production of aluminium, and is dependent upon the cost of metallic sodium. The greatest value of aluminium is, however, in its alloys, and the successful application of the intense heat of the electric arc to their production on a commercial scale marks a departure in electro-metallurgy of which we cannot overestimate the importance, rendering it possible to produce rich alloys of this metal at half the cost of any other method, and so widening the field of their application to an extent hitherto unknown. At the works of the Cowles Co., Lockport, N.Y., U.S.A., there are in operation fourteen furnaces, the electricity for which is generated by three dynamos, capable of supplying a current of 3,000 to 3,200 ampères, and E.M.F. of 55 to 60 volts. These furnaces can produce 2,500lbs of aluminium bronze (10 per cent.), and 1,800lbs of ferro-aluminium (10 per cent.), or a total yield of 430lbs of contained aluminium per 24 hours. The English works of the company at Milton, Staffordshire, contain twelve furnaces, with a 500 horse-power dynamo, built by Messrs. Crompton, and said to be the largest machine in England, and probably in the world; it furnishes a current of 5,000 to 6,000 amperes, with an E.M.F. of 50 to 60 volts. The production of these works is 2,300lbs. aluminium bronze (10 per cent.), and 1,800lbs. ferro-aluminium (10 per cent.), per 24 hours, or 410lbs. of contained aluminium. The furnaces are rectangular in form, and are of firebrick; into each end is built a cast-iron tube, through which the carbon electrodes enter the furnace; each electrode consists of a bundle of nine carbons, each 2¼ inches diameter, attached to a head of cast-iron for a ferro-aluminium furnace, and of cast copper for aluminium bronze or alloys containing copper. This head is secured to copper rods, or "leads," which can be readily connected with or disconnected from the flexible cables supplying the current. Each cable is secured to slides travelling on an omnibus bar of copper overhead, and so can be brought into position opposite the furnaces to be used. The electrodes are arranged so that it is possible, by means of a handle and screw, to advance or withdraw them from each other in the furnace. The first furnaces were lined with charcoal, but it was found that the intense heat converted it into graphite, which, being a conductor, not only meant loss of power, but the destruction of the furnace walls. This difficulty has been overcome by soaking the charcoal in lime-water, and carefully drying before use; each particle of charcoal is thus coated with insulating shell of lime. Lining the furnace is the first operation; the bottom of the trough is covered with a layer of prepared charcoal, the electrodes are arranged in the furnace, and a "former," a sheet-iron box without top or bottom, each end being arched to fit over the electrodes, is inserted; charcoal is then rammed into the space between it and the firebrick walls. This done, the charge of ore, mixed with coarse charcoal and the metal to be alloyed with the aluminium, in form of turnings or granules, is placed inside the iron box, after which this is carefully withdrawn; the space between the electrodes is bridged by some broken pieces of carbon, the charge is covered with coarse charcoal, and the furnace closed by a heavy cast-iron cover having a hole in the centre for the escape of gases evolved during the reaction; the cover is luted so as to prevent the entrance of air. The commencing current is about 3,000 ampères, and is gradually increased to 5,000 ampères; a "run" occupies about 1½ hours. The furnace is allowed to cool; the next, ready charged, is connected with the cables, so that the process is a continuous one, the furnaces being successively charged and connected. The crude metal from the furnace is then re-melted in an ordinary reverberating furnace, a sample being taken from each run and assayed for aluminium. The nature of the reaction that takes place in the electric furnace is not very easy to ascertain; the conditions are unlike those of any other known: the reduction of the aluminium taking place in absence of air and in presence of an enormous excess of carbon, it may be assumed that, at the intense heat of the electric arc, the ore melts and gives up its oxygen to the carbon:—

$$Al_2O_3+3C=3CO+Al_2.$$

In the absence of copper, the liberated aluminium absorbs carbon and is converted into a carbide of the metal. The escaping gas which burns at the orifice in the cover is almost entirely composed of CO. The most valuable of the alloys are those with copper. Aluminium bronze has great tensile strength. A bar containing 11·0 per cent. aluminium made by the electric furnace, and tested by the Leeds Forge Co., Limited, gave a tensile strain of 57·27 tons, or 128,400lbs to the square inch. One, containing 7·5 per cent. aluminium, tested by Professor Unwin, broke under 36·78 tons = 89,743lbs to the square inch. In resistance to compression this alloy equals the best steel; its transverse strength, or rigidity, is about forty times greater than ordinary brass. Its elastic limit is higher than that of mild steel, and it can be worked at a bright red heat as easily as wrought iron. Its mechanical and physical properties render it useful for every variety of metal work, its high price only having hitherto restricted its use. Its enormous strength and anti-corrodible qualities recommend it as valuable above any other alloy for propeller blades, stern and rudder frames, and for hydraulic and engineering work generally. Above 11 per cent. the alloy becomes brittle, and at 20 per cent. can be powdered readily in a mortar. The addition of small qantities of aluminium lowers the fusing point of iron, and this is utilised in the "Mitis" castings. It ensures freedom from blow-holes, increased tensile strength, and high elastic limit. Mr. Keop found that 0·1 per cent. aluminium raised the transverse breaking strength of a ½-inch bar, 12 inches long, from 379lbs. to 545lbs., or 44 per cent., and the resistance to impact from 239lbs. to 254lbs., or 6 per cent. The tensile strength of mitis castings may be as high as 27 tons per square inch, with an elongation of 20 per cent. Another alloy made in the electric furnace is silicon bronze, which, owing to its great strength and tenacity, its resistance to corrosion, combined with high electrical conductivity, is, perhaps, the best metal extant for electric light, telephone, and telegraph wires.

SECTION C.—GEOLOGY.

CRYSTALLINE SCHISTS OF NORWAY.

Dr. ARCHIBALD GEIKIE, director-general of the Geological Survey, read a paper "On the Origin and Age of some of the Crystalline Schists of Norway.' The author described the chief results of a recent journey made by him in Norway or the purpose of comparing the archæan and palæozoic metamorphic rocks of that country with those of the Highlands of Scotland. He directed his attention to the districts where recognisable fossils occur in strata surrounded by crystalline schists, and where he hoped that the actual relations of the fossiliferous sedimentary formations and the schistose rocks could be definitely ascertained. These districts were — first, the country lying to the south and east of Trondhjem, embracing the lower parts of the valleys of the Orkla and Gula rivers; and, second, the southern part of the peninsula of Bergen. The author pointed out the close resemblance of these Norwegian rocks to those that constitute the main mass of the central and southern Highlands of Scotland. He showed that they could be easily distinguished from the archæan series in both countries; that they were essentially of sedimentary origin. but with important volcanic intercalations; that the fossil evidence from Norway proved them in that country to be of Silurian age; and that a similar conclusion as to the age of those in Scotland might be drawn from the stratigraphy of the Highlands.

A discussion followed, the president stating that he had travelled much over the south part of the Scottish Highlands, and was perfectly satisfied that they were altered sedimentary deposits. He had no doubt that they would by and by find fossils in the less altered rocks, as well as in the highly crystallised limestone of the Highlands.

METAMORPHISM OF SKIDDAW SLATES.

Mr. J. E. MARR, M.A., Sec. G.S., read a paper on "Dyramic Metamorphism of Skiddaw Slates." In the belt of Skiddaw slates running along the west side of the Crossfell escarpment from Melmerby to Roman Fell, several large masses of quartz occur, tending generally in a W.N.W. to E.S.E. direction. The best exposure was on the east side of Brownber. There the large quartz veins were evidently intruded along bedding planes before the main folding took place. They were now extremely contorted, and the slates had undergone alteration, being converted into a rock composed largely of mica and secondary quartz, and exhibiting *answeichungschwage*—in fact a mica-schist. Many cubes of pyrites were scattered through the rock, and had been slightly deformed, with formation of a fibrous mineral around the crystals. The slates were not greatly altered except in belts where the quartz vein came, and as these were, as above stated, formed before the principal folding, it would appear that the alteration of the slates was due to the differential movement produced between the hard quartz and soft slate, as shown by the universal slickensiding of the divisional places.

LOWER SILURIAN FELSITES OF SOUTH-EAST IRELAND.

Dr. FREDERICK H. HATCH, of H.M. Geological Survey, read a paper on the "Lower Silurian Felsites of the South-East of Ireland." In the paper there were communicated twelve analyses, by Mr. J. Host Player, of felsites from the lower Silurian (Bala) beds of the counties of Wicklow and Waterford. The main point brought out by these analyses was the almost entire absence of lime and the presence of potash and soda in varying proportions.

THE GRANITES OF DARTMOOR.

Mr. A. R. HUNT, M.A., F.G.S., read a paper on "The Age of the Granites of Dartmoor and the English Channel." There had been no evidence of veins in the trawled channel rocks. The Dartmoor granites abounded in veins both injected and infiltrated. The Channel granites and greisses had been considered by experts archæan. The Dartmoor granites had been commonly considered post-carboniferous on the evidence of the veins injected into the culm-measures.

THE ISLAND OF PAROS.

Mr. R. SWAN, F.C.S., read a paper on "The Island of Paros, in the Cyclade, and its Marble Quarries." He said the rocks were much disturbed and folded, and often dipped at high angles. The ancients avoided the marble lying near the axis of elevation, that being of less good quality than in other parts. A Greek company formed a few years back to work the marble attacked it here, where it could be got at least expense; this discredited the marble in the market, and the company failed, having spent over £160,000 in a railway, landing pier, and elaborate installation of various kinds. There was a good deal of excellent coloured marble on the island; but, not having been used by the ancient Greeks, this was little known.

CRYSTALLINE SCHISTS OF THE LEPONTINE ALPS.

Mr. **Watts** read a note by Professor Bonney on "The Alleged Occurrence of Fossils in the Crystalline Schists of the Lepontine Alps." Additional evidence has been obtained, not in that district only, in support of the opinion already expounded by the author, that the crystalline schists of the Alps existed as crystalline schists anterior to any rock which can be recognised as of mesozoic or even of palæozoic date.

PRESSURE ON CRYSTALLINE LIMESTONES.

Mr. **Watts** read a paper by Prof. Bonney "On the Effects of Pressure on Crystalline Limestones." The author concluded that in limestones pressure alone was a comparatively minor agent in producing crystallisation, while it often rendered those which were once crystalline more fine-grained in structure.

THE AMYGDALOIDS OF THE TYNEMOUTH DYKE.

Professor **Lebour** read a paper by Mr. J. J. H. Teall on "The Amygdaloids of the Tynemouth Dyke." He said they might summarise the history of the rock so far as it was recorded in microscopic structure as follows:—1. Development of granular aggregates of a felspar allied to anorthite under plutonic conditions. 2. Addition of felspar substance to the external portions of the granular aggregates, and the consequent production of crystalline form. 3. Development of lath-shaped felspars. 4. Separation of augite. 5. Formation of vesicles owing to the separation of gas from the magma. 6. Partial or complete filling up of some of these vesicles with interstitial matter. 7. Consolidation of the interstitial matter. 8. Filling up of the vesicles remaining empty after final consolidation with carbonates.

DR. NANSEN ON GREENLAND.

Dr. **Nansen** read a paper on Greenland. In the course of his remarks he said the scientific results of the expedition could not at present be stated, the many observations not having been worked out by the respective savants to whom they had been submitted. There were, however, some points which, especially in geological and meteorological senses, were prominent. At first he thought the shape of the island was of importance. Many geologists had suggested that the interior of Greenland was ice and snow-clad, but there were others who were of opinion it was not snow-clad. Amongst the latter he would mention the famous Nordenskiold. He would not there criticise Nordenskiold's theories. The expedition from which he (Dr. Nansen) had just returned had, in his opinion, fully proved that they could not be right so far as concerned Greenland. The expedition had, he believed, settled the fact that that part of Greenland was not only ice-clad and snow-clad, but had a mighty shield-shaped covering of snow and ice, under which mountains as well as valleys had quite disappeared, and where they could not even trace the configuration of the land and mountains. Whether this was also the case in the most northern parts of Greenland he dared not yet say. This must be decided by a new expedition, and he thought the question to be one of the highest interest. At present they had only to consider the southern parts of Greenland. The ice covering had the shape of a shield. Rather rapidly, but regularly, it rose from the east coast, reached a height of 9,000 to 10,000 feet, was rather flat and even in the middle, and fell again regularly towards the west coast. What had occasioned the regular shape? What was the configuration of the land beneath? In the interior of Greenland there must be mountains and valleys as well as near the coast. That there were on the coast deep fjords and lofty mountains, very like those of Western Norway, and that they had just the same wild and prominent character in some places they already knew: they were perhaps even wilder than ever he saw them in his own country. If they entertained the opinion that those fjords were excavated by the ice, they must also conclude that the same ice had been able to excavate valleys, and form mountains in the interior of the continent. He thought, therefore, they had no right to seek the reason of the shield-like shape of the ice in the configuration of the land underneath. The surface of the ice must have a shape of its own, which was given, not by the land, but by the meteorological circumstances. Nobody could deny that the ice must in some places have a quite enormous thickness, as it filled the valleys and covered up all the mountains, and its thickness must evidently be regulated by the quantity of snow falling. This quality must be largest towards the coast, gradually diminishing towards the interior. It was consequently very likely that the ice had not its greatest thickness just in the middle of the continent, but rather on both sides towards the coast. They might thus already *a priori* have expected to find a shape of the ice just like that observed. The surface of the snowfield in the interior was quite even, and, as it were, polished. It had a striking resemblance to the undisturbed surface of a frozen ocean, the long but high billows of which rolling from east to west were not easily distinguishable to the eye. The principal factor which made this surface so remarkable even was the wind. The levelling influence of the wind might easily be studied in their own mountains in the winter. This had been the case in Greenland, only to a much higher degree, when its present glacial period commenced. The snow grew annually, gradually the valleys were filled up, the mountains disappeared, and the snowfield was produced which they now saw. It seemed as if the ice varied a little from one year to another, but that upon the whole its quantity kept very nearly on the same level. They were not thus entitled to assume that the quantity of snow was increasing in the interior. But what was the reason why it did not increase? The principal factor in keeping the level must in his opinion, be the pressure which was produced within that immense layer of ice and snow. At one end this pressure forced the ice downwards along the sloping sides of the mountains, through the valleys and towards the sea, into which it fell in the form of ice streams and glaciers, and was carried away in the form of icebergs or was melted. But the pressure brought the ice to the sea not only in the form of ice, but also, and certainly in larger quantities, in the form of water. As was generally known, ice had a peculiarity that by pressure it could be transformed into water at temperatures lower than the melting point of ice. He did not think, however, that it was principally in that manner that the pressure contributed to the melting of the snow, as such a high pressure, and, consequently, a very considerable quantity of snow and ice was necessary to lower the melting point of the ice only one degree. He thought that the most important factor was the warmth produced by the pressure and friction. For glacialists, he thought the observations made on that expedition must be of great interest, and must contribute largely to confirm many of the glacial theories. A careful observation of a snow and ice covering like that of Greenland was, in his opinion, of great importance for the theory of the formation of valleys and fjords by ice. The ability to excavate the ground beneath must be, therefore, in quantities of ice like those observed there. It seemed the more they studied Greenland, its coasts, and its inland ice, the more convinced must they feel of the great ability of the ice to form fjords and valleys to a great extent. He thought that the best way of observing the problems of the great ice age was to go and examine the places where similar conditions were to be found, and no better place could be found than Greenland. But Greenland was a vast region. The expedition in which he engaged was the first to cross it, and he hoped it would not be the last.

Considerable discussion followed, the president stating that the experience of Dr. Nansen bore out the common belief of geologists that the thickness of the ice during the ice period must have been very great. When they listened to Dr. Nansen it was like listening to a man who had come back from the ice period to tell them exactly what appearance Europe presented at that time. The description given of Greenland by Dr. Nansen would apply more or less directly to the aspect presented by our own northern regions in the far-back glacial period. He quite agreed with Dr. Nansen that, if the ice sheet in Greenland could be melted away, they would find beneath it a country very much like that of Northern Scotland or Norway.

Dr. Nansen was thanked for his paper.

SECTION D.—BIOLOGY.

THEORIES OF HEREDITARY TRANSMISSION.

Mr. Poulton, at the outset, referred to the proceedings on the previous day in the Anthropoly Section, and spoke of Sir William Turner's address as pleasing evidence that the men of wider experience were beginning to take part in the discussion of this subject, which had formerly been confined to the younger biologists and to those who had written upon or otherwise specially devoted themselves to the question. It was satisfactory to notice that the discussion had now assumed wider proportions. It was just two years since Professor Lankester had introduced the subject at Manchester, on which occasion Professor Weismann took part in its discussion. His object on the present occasion was to continue the discussion then begun, and specially to direct attention to the facts and theories which had been brought forward during the two years that had since elapsed. Professor Newton's most interesting presidential address on that occasion touched upon the early struggles which had been waged around the question of evolution, and indicated how the change in outside opinion might have been gauged by the tone of the discussions in Section D of the association. We were now passing through the greatest crisis in the history of the theory of evolution since the first appearance of the "Origin of Species" thirty years ago, and it might similarly be that, on the subject he was now presenting to their notice, the state of scientific opinion generally could be gauged from the debate in that section. Having defined what he meant by the term "acquired character" as that which was produced by the incidence of external forces upon the individual body, as opposed to the mere development of inherited tendencies in the individual, Mr. Poulton proceeded to deal with the evidence which had been put forward in support of the hereditary transmission of acquired character. The evidence for the transmission, he said, might be direct; such a proof would be afforded by the transmission of mutilations or any other characters undoubtedly impressed on the individual by external influences. The evidence might also be indirect: thus if it could be shown that evolution would be impossible without the aid of this principle, we should be compelled to accept it. The indirect evidence was of three kinds—viz. (1) the fact of variation; (2) the effects of the use and disuse of parts; and (3) the phenomena of instinct. All these were said to be inexplicable without the aid of this transmission. Each of these lines of evidence was touched by the publications of the last two years. Among the direct proofs, many supposed cases of transmitted mutilation had been refuted by Professor Weismann, who had shown that this evidence must be always received with the gravest suspicion. Some experiments by a speaker, in which mutilations were inflicted very early in development, viz. (during the larval life of an insect), led to no transmission of the results. Certain direct evidence supposed to be afforded by plants was shown by Professor Weismann to point against the transmission. The effects of millions of years of alternating sunlight and darkness, though very mared in the case of each individual, had no effect on its offspring. Turning to indirect evidence, Darwin's "Life and Letters" showed that he was strongly influenced by these considerations. He could not explain variation without the transmission of the effect of environment on the ancestors. But the effect of environment on the germ-cells through the parental cells would not imply such transmission, unless the offspring showed the same effects as those wrought on the parents, that this had never been proved. The facts known about identical twins were quoted by Gallon and Weissmann as showing that the peculiarities of the individual were almost exclusively predetermined in the ovum. Professor Windle had recently argued that almost all examples of monstrosity were due to peculiarities of the ovum, and not to external forces. The supposed hereditary effect of *use and disuse* were unsupported by any proof that the modification of organs affected by use or disuse had been more complete or more rapid than that of organs not so affected. An apparent difficulty in the region of instinct, suggested by Professor Romanes, did not appear to support his conclusions. He instanced the instinct of certain wasps to sting the nerve-centres of their prey, and argued that this was at first an intellectual action, the wasp having watched the effect of its sting. But in this and other parallel cases the successful effect was felt by the offspring of the wasp rather than the wasp itself. The case was, therefore, better explained by the operation of natural selection, and the operation was probably non-intelligent from the first. In conclusion, Mr. Poulton mentioned that he had just received a letter from Mr. Russell Wallace, in which the writer had made the significant prophecy—"I think you will have a grand 'shindy' in Section D this morning." (Laughter and applause.)

Mr. Francis Galton, F.R.S., who was warmly applauded, next read a paper entitled "Feasible experiments on the possibility of transmitting acquired habits by means of inheritance." Feasible experiments, Mr. Galton observed, have yet to be designed that shall be accepted as crucial tests of the possibility of a parent transmitting a congenital aptitude to his children, which he himself possessed, not congenitally, but merely through long and distasteful practice under some act of compulsion. The requirements are to eliminate all possibility of parental or social teaching, to bring up all the descendants in the same way, to make simultaneous experiments on many broods during many generations, and, lastly, to economise time, money, and labour. This list of requirements points with emphasis to experimenting on creatures that are reared from eggs, as fowls, fishes, and moths. Fowls—The largely extending practice of hatching eggs in incubators for commercial purposes, and the varied aptitudes of poultry, make them very suitable subjects. Birds are said to have an instinctive dread of various insects; hence mimetic insects, that are really good for food, are avoided by them. Do such insects exist, and could they be easily reared, which poultry would avoid at first, though experience would soon teach them to like and to eat greedily? Similarly, as regards sounds and cries, which would frighten at first, but afterwards be welcomed as signals for food, &c. Would the stocks of two breeders, one of whom adopted such experiments as those and the other did not, differ in instinct after many generations? Fish.—The experiment (quoted by Darwin) of Mobius with the pike, using a trough of water divided by a glass plate into two compartments, in one of which was the pike and in the other were minnows, were mentioned as an example. The pike after dashing at the minnows many times, and each time being checked and hurt by the glass plate, during some weeks, finally abandoned all attempts to seize them, so that when the plate was removed the pike never afterwards ventured to attack the minnows. The question, then, is, whether fish reared for some generations under conditions which compelled them to adopt habits not conformable to their natures would show any corresponding change of instinct. Of course each generation would be reared in a separate tank from its parents. Moths—Experiments have been made for the author by Mr. Frederic Merrifield with the *Selenia Illustraria*, which has two broods yearly. They are being made for quite another purpose, but have already shown the ease of breeding hardy moths on a large scale when the art of doing so is well understood. All larvæ are fastidious in their diet, but it may well be that certain food which they would not touch at first would after a while be greedily eaten, and be found perfectly wholesome. Experiments on the lines here suggested ought to show the proportion of cases in which acquired aptitudes of several kinds are certainly not inherited. They might also, perhaps, show that, in a small proportion of cases, they certainly are. Thus limits would be fixed within which doubt remained permissible. The object of the present paper was to invite experts to discuss the details of the most appropriate experiments.

A paper by Professor H. F. Osborn, on "The Palæontological Evidence for the Transmission of Acquired Characters," was set down on the agenda, but, in the absence of Professor Osborn, was not read.

Professor Flower expressed his full concurrence with what had been said respecting the great importance of the subject that had been brought before them. Up to quite recently his own impression had been strongly in favour of the views advanced by Sir William Turner on the previous day, and he was still disposed to hold thereto; but he had no facts to contribute to the discussion, as the subject had not come within the scope of his own investigation. He trusted, however, that those who were engaged in the inquiry would continue their labours, so that at some future day we might arrive at some satisfactory state of knowledge of the subject. (Hear, hear.)

Professor Vines said he had studied what Professor Weismann had written on this subject, but could not make out what he meant. (Laughter.) He had noted down some points requiring an answer from those who supported Dr. Weismann's views. One point was that the non-transmission of acquired characters was irreconcilable with the facts of the development of the embryo; and, further, if we admitted the theory we at once gave up one very important cause of the development of varieties.

Professor Ray Lankester pointed out that the position of Weismann was not that he adopted any such view as the non-transmission of acquired character, but simply in contending that nobody had yet succeeded in demonstrating the theory of transmission. The stand which he (the speaker) wished to take up on this question was that those who assumed transmission of acquired character were assuming too much. Let them bring forward a single demonstrative case of transmission. They wanted demonstration, because it was demonstration that they were waiting for. Professor Lankester added that he was not at all prepared to accept Weismann's views as to the impossibility of the thing. What he had written tended rather to show only its improbability.

Dr. G. J. Romanes said his own opinion coincided very much with that expressed by Professor Vines. At the same time he did not wish to be understood as holding a brief in favour of pangenesis. What had already been advanced failed to recognise the very great distinction between acquired and congenital characters in respects to their transmissability. But this was well known to Darwin and many in this country before Weismann had commenced to write on the subject. The new theory of heredity put forward by Weismann failed to co-ordinate with the phenomena of reproduction and of repair. He said that theory made no provision for co-ordinating these two things, whereas, on the other hand, the theory of Darwin did make such provision. Any adequate theory of heredity was bound to take cognisance of the similarity between these two.

Prof. Marshall Ward observed that the supporters of Weismann stood in the position of challenging their opponents to bring forward cases, and they would be prepared to give them the fullest investigation.

Prof. Herdman, of Liverpool, said he would like to accept Weismann's theory of the germ plasma, but to admit the possibility of acquired character being occasionally transmitted.

Miss Becker (who spoke from the body of the hall) complained that there was a want of precision in the use of such terms as "acquired character." For instance, to include mutilation in this category was a contradiction in terms. At the time of its first appearance, Darwin's theory of pan-genesis burst upon her like a revelation, and had since held possession of her mind. In a letter received by her from Mr. Darwin some years ago, he said that his latest theory had not been received with the same favour by his scientific friends—with the same favour as had been accorded to his origin of species. But, like the mother with the imperfect child, he regarded it with all the more favour on that account.

Mr. Francis Galton wished to entirely disconnect himself from Weismann's theory of the germ plasma, which he regarded as reactionary.

Mr. Poulton then referred to some of the criticisms that had been offered, and expressed his regret that Miss Becker's letter had not been included in the Darwin collection, and the thanks of the meeting having been conveyed to Mr. Poulton and Mr. F. Galton, the discussion terminated.

DEEP SEA DREDGING,

A Committee's report was presented on the improvement of the deep sea tow-net, explaining facilities for closing the net in deep waters, Mr. G. Bourn contributed some notes on the same subject.

THE OAK LEAF AND THE GUELDER ROSE.

Sir John Lubbock contributed two papers. In the first of these, on "The Shape of the Oak Leaf," he said: We are so accustomed to the form of the oak leaf that it does not strike us as anything peculiar, and comparatively few, perhaps, have ever asked themselves why it should be as it is. And yet it is peculiar—unlike that of any of our forest trees and those of the evergreen oaks so abundant in hotter countries. In botanical phraseology, they are "deciduous, oblong-oblanceolate or oblong-elliptical, sinuated, with blunt lobes extending not more than half-way down to the mid-rib." The sinus between the lobes is generally rounded off at the bottom. Again, though I have not found this mentioned in the botanical works which I have consulted, they are rarely symmetrical, the lobes of the two sides not corresponding. The three points then which give the oak leaf its peculiar form are:—1. The deep, rounded sinuses. 2. The want of symmetry of the two sides. 3. The oblong or oblanceolate outline. I do not know of any attempt to explain this peculiar form. As regards the sinuses, Kerner suggests that they are intended to permit the passage of light to the lower leaves. I would not deny that the space between the lobes may be of some advantage in the manner suggested by Kerner, but I greatly doubt whether this is the main or primary explanation. That which I would suggest is as follows. The leaves of the evergreen oaks are entire, and small in comparison with those of the English oak. During the winter and early spring they are protected by a series of brown scales, inside which they lie, and with which they form the well-known buds which are so familiar to us, and which are both small and short in proportion to the size of the leaves themselves. In cooler and moister regions, on the contrary, there is, as we know, a tendency for leaves to become larger and deciduous. I will not now enter into the reasons for this, but the fact will not probably be denied. These influences do not, however, affect the outer scales, which remain as before without any increase of size. But as the leaves have increased in size and the scales have not, the leaves can no longer retain their original arrangement in the bud. If, for instance, we compare the buds of the oak and of the beech, we see that while the leaf of the oak is longer than that of the beech, the bud of the oak is on the contrary shorter than that of the beech. Under these circumstances, what must happen? The leaf grows and becomes longer than the bud; it is therefore necessarily bent into a curve. But an entire leaf, if thus throw into a curve, would necessarily fall into folds, the number being determined by the number of ribs or veins. For such folds, however, there would be no room within the narrow limits of a bud, or rather perhaps they could be inconvenient because they leave more or less empty spaces. This may be rendered more clear by taking a piece of cloth or of paper, folding it up, and then throwing it into a curve. It will then necessarily fall into one or more folds. If it were strengthened as an oak leaf is, by three or four side ribs, there would be a fold between each two ribs. As a matter of fact, however, from the absence of space the membrane where the fold would be is not actually developed. We may imitate this by removing them. If this be done, the result will be the formation of sinuses, rounded at the base, closely resembling those so characteristic of the oak leaf. These sinuses are due then, as I believe, to the curvature of the leaf owing to the shortness of the bud in comparison with the length of the leaf. The young leaf is not only curved, it is wrapped round the interior leaves. The result of this is that one side of the leaf is folded within the other ; the one, therefore, being on the outer side has more space than the other. The two sides of the leaf are in fact differently situated, and this, I believe, accounts for the second point, namely, the want of symmetry. The oblong form is an advantage from the way the leaves diverge from the stalk. In this manner the interesting peculiarities of the oak leaf may be accounted for. The paper was illustrated by diagrams, specimens, and models, and the probability of the cause suggested being the true one was enforced by the application of a similar argument which clearly explains the peculiar form assumed by the very interesting and curious leaves of the tulip tree.

In his paper "On the Leaves of Guelder Roses," Sir John said :—We have in this country two species of Guelder rose. They are nearly allied, but the leaves are very dissimilar ; those of the *Vibernum lantana* being oval or ovate and when young very hairy ; those of *V. opulus* 3-lobed, smooth, and provided with stipules. These differences are very interesting, but no one had yet attempted to explain them. Sir John pointed out that the young leaves of *V. lantana* are sufficiently protected by their hairy covering, and are consequently left bare. This is not the case with *V. opulus*, in which the leaves are glebrous. The outer leaves, however, become tough and leathery and form a covering within which the other, or true, leaves are developed. To economise space these leaves are folded more or less like a fan in the same manner as those of maples, sycamores, planes, &c., and this gives them their lobed form. As regards the stipules, he observed that the genus contains some 50 species, of which about 40 have oval leaves without stipules, while the remainder have lobed leaves, with stipules. The presence of the stipules seems, therefore, to go with that of the lobes. He believes that they assume their peculiar thread like form so as to fill up a space which would otherwise be left empty in the bud. Maples have no stipules, but in them the younger leaves in the bud just fill up the interspaces left between the older ones. In the lobed leaved Guelder roses this is not the case, but a space remains, which is just occupied by the stipules. The paper was illustrated by diagrams.

In the discussion which followed, Prof. Vines, Prof. Bower, Prof. Hartog, and Mr. A. W. Bennett took part.

ELECTRIC ORGANS IN FISH.

Professor J. Cossar Ewart, of Edinburgh, read a paper on "The Modification of Electric Organs in Elasmobranch Fishes."

Dr. Romanes said the investigations which Professor Ewart had conducted along with their president, Dr. Burdon Sanderson, were amongst the most remarkable of modern times.

MIGRATION OF FISHES.

Professor Ewart also read a paper on this subject. He said that during the last few years, while naturalists had been devoting considerable time to fishery questions, much had been done in determining the nature of the food and the time of spawning, and especially the nature of the spawn of some of the food fishes. Little light had been thrown on the habits of either inshore or deep sea fishes, and practically no advance had been made towards solving the extremely difficult question of migration. There seemed little chance of their being able to arrive at any general conclusions as to the movements of the fish by studying their food, and it would be far more profitable to study carefully their movements during the spawning season.

SECTION E.—GEOGRAPHY.

THE GREAT CENTRAL ASIAN TRADE ROUTE.

Col. Mark S. Bell, V.C., R.E., read the first paper on "The Great Central Asian Trade Route from Peking to Kulja and Semirechensk, and to Yarkand and India." Kashgaria, said Col. Bell, is reached from Peking by the Ala-shan or, generally speaking, desert camel route, *via* Kwei-wha-cheng and Barkul, and the Wei Valley route, a cart road leading through Pau-ting-fu, capital of Chili ; Tai-yuen-fu, capital of Shansi ; Si-nan-fu, capital of Shensi ; Lan-chow-fu, that of Kansuh and Hami, crossing the Gobi desert between An-si-chow and this latter place. The route would be classified by the Chinese into stages as below, and would be each assumed to take eighteen days of travel, *i.e.*, Peking to Tai-yuen-fu, 375 miles ; Tai-yuen-pu to Si-nan-fu, 438 miles ; Si-nan-fu to Lan-chow-fu, 449 miles ; Lan-chow-fu to Su-chow, 482 miles ; Su-chow to Hami, 418 miles ; and thence onwards, Hami to Hung-miot-za, 408 miles ; Hung-miot-za to Ili, 400 miles ; Hami to Karashahar, 420 miles ; Hung-miot-za to Karashahar, 256 miles ; Karashahar to Aksu, 373 miles ; Aksu to Kashgar, 311 miles. Few Europeans have traversed this route since the days when the conquests of Ghenghis Khan and his successors opened Asia to the inspection of Christendom, and none have done so in its entirety since the Mahammadan rebellion in the north-west of China before 1887, when the reader of this paper did so. After describing the route through Shansi to Si-nan-fu and touching upon lateral communications and the mineral and agricultural resources of the districts traversed, the commercial importance of the Wei Valley was dwelt upon, and it was shown how this centre of gravity and of resistance of Mid-China is cut off from the rest of the empire by mountainous or hilly regions at present most difficult to traverse. The routes possible to be followed by railways were reviewed, and the necessity of this rapid communication to China, if she desire to retain possession of her north-west provinces and Kashgaria, was pointed out. From Si-nan-fu the route turns to the north-west and leaves the fertile loess valley of the Wei to traverse the once fertile but now devastated and depopulated hills and valleys of Shensi and Kansuh to the confines of the Gobi desert at An-si-chow. The description of the route which crosses passes elevated 10,000 feet is followed by that of the Gobi route to Hami. In conjunction with them are considered the lateral communications, resources of the district in coal, &c., and the inhabitants both of this wedge of cultivation held by the Chinese in the past as a means of gaining access into Central Asia, and of its lateral mountains and deserts. The importance of this bottle-shaped portion of Kansuh, the one and only natural route between the extreme east and the extreme west, as a means of communication between Central Asia and Mid-China, was pointed out, and its fitness for a railway route and its influence over such on our Chinese trade, discussed. From Hami the route over the Tian-shan to Baikul and through this range and along its northern glacis slopes to Hung-miot-za is described, as well as the falling away of this great range here, and the natural access that at this point exists between the Tian-shan-peh-lu and the Tian-shan-nan-lu, *i.e.*, the two great historical routes from Hami to the north and south of the Tian-shan range. This section of the Central Asian trade route and of the Tian-shan range, with its arid deserts and paradises of oases, has not been previously described in detail. An account of the Tian-shan-peh-lu and nan-lu was followed by a few remarks on the routes into Russian Turkistan and Ladakh from Kashgar and Yarkand. As China is of interest to Great Britain as a possible military ally in the future, and as a present certain and important commercial one, the study of the political geography of the country traversed by this important cart route of the past and coming railway one in the future is a very necessary one to our Eastern interests, and requisite to enable us to foresee coming events and to mould them to our advantage. As an incentive to this study the paper on this trade route has been prepared.

At the conclusion of the paper, Mr. **HOWARTH**, M.P., said that while none could denounce too strongly the conduct and policy of individual Russian commanders, he conceived that every advance made by Russia in Central Asia had been a huge and permanent gain to civilisation, and a great many of these advances had been absolutely justified. A great nation, which had on its frontier a number of nomadic and predatory tribes, was obliged to enlarge its frontiers. It was inevitable that these frontier tribes should eventually be brought within the sphere of action of a great neighbouring Power, whose civilisation must be protected.

INDUSTRIAL AND COMMERCIAL PROGRESS IN CHINA.

Mr. R. S. **GUNDRY** read the next paper, which was on "Industrial and Commercial Progress in China." Premising that the wide differences in character and habits of thought between ourselves and the Chinese make it difficult to convey to an English audience an accurate impression of the situation, the writer went on to sketch the leading feature of Chinese industry and commerce in so far as they concern, and have been affected by, foreign enterprise. Beginning to move at a time when she had been defeated in a foreign war, China's first efforts were to provide herself with the warlike material which experience had shown her to be so powerful. Hence the early construction of arsenals and steamers. The beginnings of telegraphy and the acceptance in principle of railways were due also, in a measure to warlike stress in connexion with Kulja and Tonking. And mining was recognised largely as a means of providing for all this additional expenditure. But imperfection of knowledge, jealousy of foreign supervision, and a disorganised condition of finance which involves venality and harassing taxation, retard a progressive movement, to which the *literati* who constitute the mind of the nation are still as a body disinclined. The imperial finances, too, have been strained by a series of wars, rebellions, and disasters; and distrust of their officials prevents native capitalists from investing money in enterprises with which the officials persist in meddling. The great staples of tea and silk are severely menaced by the competition of India and Ceylon in the one case and of Southern Europe in the other; and the Chinese are slow to accept improved methods of preparation which would enable them to hold their own. China tea is heavily handicapped also by taxation, in competition with its duty-free rival. Fiscal hindrances, imperfect communications, and consequent cost of transport have much to do with the slow development of trade. But the wide prevalence of domestic industry, and difficulties of exchange caused by the demonetisation of silver, tend also to check the anticipated growth of demand for our manufactures. There seems every prospect that more railways will shortly be constructed, and that machinery will be tentatively admitted for purposes of industrial manufacture. But much time, a more wide-spread desire for progress, and radical financial reform will be required before China is likely to rival Japan in the completeness of its transformation.

THE COMMERCIAL RIVALRY OF ENGLAND AND RUSSIA.

There was no discussion on this paper, and the next was read by the Hon. G. Curzon, M.P., on "The Central Asian Railway in relation to the Commercial Rivalry of England and Russia." After reviewing the general economic policy of Russia, the author proceeds to the consideration of the new field of activity in Central Asia, which was opened up and dependent upon the Transcaspian Railway. The area of Russian influence and command of trade routes was threefold:—I., The Khanates; II., Afghanistan; III., Persia. The Russians had a monopoly of the import trade into Bokhara. The transit trade from India was destroyed. In Northern Afghanistan there was on increasing Russian trade, fed by the Transcaspian railway, and in Persia Russian commercial influence had increased, while British influence had declined. In the Khanate of Bokhara Russia, by means of the Transcaspian railway, had acquired a complete monopoly of the native market. It was impossible for England to enter into any independent commercial relations with the Emir of Bokhara as it would be for Russia to make a similar arrangement with the Maharajah of Kashmir. The utmost that we could do was to assist the Indian transit trade through Afghanistan, by prevailing upon Abdurrahman Khan to lighten the extravagant dues imposed by his office of customs. He had not much faith in this remedy, and looked on the trade of Bokhara as lost. In Afghanistan, British commerce was not making the headway that might be expected in the south, and was suffering from Russian competition in the north. He would like to see Great Britain exercise a much greater control over a State which was admitted to be solely under the suzerainty of this country, and from which we were entitled to demand substantial returns for our considerable outlay and immense responsibilities. He would like, on the Indian side, to see railroads pushed further into Afghanistan, certainly as far as Kandahar, and possibly as far as Kabul. British ascendency in that country was far more likely to be perpetuated by such methods than by intermittent campaigns, or even by regular taes of rupees. In Persia, while Russian ascendency in Khorassan was at present balanced by British ascendency in the south, yet in the western and northern zones of influence, British trade was declining, and Russian trade progressing. In these cases our share of the spoils might be re-vindicated by the bestowal of greater attention upon the tastes and fashions of our Persian customers, and by the employment of trained middlemen or brokers speaking the native language and understanding native customs, who should both supply the English manufacturers with information and facilitate the discharge of business on the spot. But in Persia, as elsewhere, our control was only to be south and projected into the east, north, and west, by the new and bloodless weapon of nations, viz., the extension of communications by rail. The principal trade routes of the Orient are marked out by physical conditions and by immemorial usage. But those who aspired to their control must realise that, though the routes remained the same, the methods had changed. Caravans were doomed, and goods waggons drawn by steam must take their place. It was to her quick realisation of this fact that Russia owed the extraordinary success that was now attending her commerce in Central Asia, and that had swollen her exports over her Asiatic border from £2,470,000 in 1884 to £3,530,000 in 1886; and her imports over the same frontier from £3,620,000 in 1884 to £4,530,000 in 1886. The lesson that she had taught us in Transcaspia and the Khanates we should apply in Persia. British trade with Khorassan could only be recovered, with Teheran can only be extended, and with Ispahan could only be permanently secured by the introduction into Central and Southern Persia of a railway system connecting the principal towns and in communication either with the ports on the Gulf or, as was even more desirable, with the already existing British railway in Beluchistan. This line supplied the natural starting point from which a railroad could be pushed forward principally into Sustan, a region of great potential fertility, and continued thence to Kerman Yeyd and Ispahan, which might also be approached by improved road communication from Shustar on the Karun, and, perhaps, ultimately be connected by rail with Kermanshah and Teheran. This was an ambitious, but it was both a practicable and a pacific policy. He saw no reason why, if the attention of the people of this country could be drawn to the critical condition of British commerce in Central Asia, and if they could be convinced, as was easily done, of the value and importance of its maintenance and extension, they should not merely acquiesce in but should insist upon a policy that was directly devoted to the ends he had described, and that would unquestionably be fraught both with profit to ourselves and with blessings to the peoples of the East.

WIND ACTION IN THE NILE BASIN.

A paper on "Wind Action in the Nile basin" by Mr. W. J. Flinders Petrie was next read by Mr. **Mackinder**, M.A. The following is an abstract of the paper :—The underlying motions of the Delta are depression on the coast, and upheaval at Ismailiyeh. Above these movements great changes have been made by wind action ; in some sites at least eight feet of ground have been removed, and deposited in the water. This has partly caused the great retreat of the Red Sea head, and tends to form the characteristic swamps of this district. Formerly the Delta was a desert track, with valleys inundated by the Nile. Before historic times the Nile valley was deep in water, partly estuarine, partly fluvial, and great rainfall then took place. That this was in the human age is shown by the position of worked flints.

LAKE TANGANYIKA.

Captain **Hore** next read a paper on Lake Tanganyika. The following is an abstract of the paper :—1. The geographical position of the lake, as occupying the central depression of the heights of Africa, from the surrounding barrier of which descend the furthest sources of the great rivers ; its outlet, and remarks upon certain earthquake phenomena and the aspect of the depression and of the bed of the lake. 2. General description of the lake, with results of meteorological observations and notice of scenery, and aspects of the lake under various changes of weather. 3. The natives living on the shores of the lake and within the central depression as representing all the great African families ; and some account of their arts and industries, and of the produce of the lake region. 4. African routes and lines of communication as converging towards or crossing the lake, and the present available approaches to the lake from the east coast. 5. The position of the lake amongst and in relation to present claims and operations in Central Africa, with notice of what of European enterprise has already been achieved on the lake.

THE PORTUGUESE IN AFRICA.

This paper was followed by one on "Recent Portuguese Explorations in Africa," by Mr. J. Batalha-Reis. He said that the chief Portuguese explorations of this century commence with its earliest years. In 1802, the expedition sent out by Col. Honorato da Costa from Angola, which traversed the whole of the continent from the basin of the Kassai to the basins of the Lualaba, Luapula, Bangweolo-Bemba, and North Loangwa, arrived at Tete in 1811. In 1804 and 1805, Father Cannecatim published his dictionary and remarks upon the Bunda, or Angolense, language, and the narrative of his journeys in Africa. In 1831-1832, Monteiro and Gamitto explored the region between Lakes Nyassa, Bembo-Bangweolo, and Moero and the river Zambeze. In 1838-1848, Major Francisco J. Coimbra made his journey from Mozambique to Benguella, across Africa, and visited the lakes to the north of Kalaari. In 1843-1847 Joaquim Rodrigues Graga went from Golunga to Bié, and thence to Lunda, almost at the eastern extremity of the basin of the Kassai. For many years Silva Porto travelled and explored the territories between the valleys of the Kwanza and that of Liambye on the Upper Zambeze. In 1852-56 his expeditions travelled from the Upper Zambeze to the Upper Luangué, and between the basins of the Zambeze and of the Congo, passed to the south of Nyassa, and crossed, diagonally, the region between the Nyassa, the Rovuma, and the sea. In 1855-56 Montanha and Teixeira explored the territories between Inhambane, the Limpopo, and the north of the Transvaal. In 1877 expeditions of engineers were sent by the Portuguese Government to all their colonial provinces of Africa, and instituted the investigations and works which have gone on up to now, and from which the first railways in these regions had their commencement, the more perfect knowledge of many of the regions being also due thereto. In 1877-78 Serpa Pinto crossed the continent of Africa from Benguella to Bié, and thence, by the affluents of the Kwando, to the Upper Zambeze, thence to the lakes north of Kalaari, thence through Bochuanaland to the Transvaal and Natal. In 1877-80 Capollo and Ivens went from the valley of the Cunene to the valley of the Kwanza, and thence to that of the Kwango, which they investigated nearly as far as lat. 6° S. In 1883 Antonio Cardoso visited the districts which lie between the river Save and the upper valleys of the river Buzi. From 1880 Paiva d'Andrade has been exploring the lands which lie between the Zambeze and the valleys of the Save and Buzi. In 1884-1885 Capello and Ivens travelled right across Africa, from Mossamedes to the rivers Cunene, Cubango, Liambye, Lualaba, Laupala, Lake Bemba, and thence to the Zambese, from near the mouth of the Kafue to the sea. In 1885-1886 Augusto Cardoso traversed from Ibo to the Nyassa, and thence by the Shiré to the Zambese. In 1884-1888 Henrique de Carvalho and Sisenando Marques investigated the territories between the Cwanza and the Kassai, in the districts of Lunda. These are the better known travels, but the Portuguese have undertaken very many less extensive but more minute explorations than these, which are almost entirely unrecognised, and cannot be mentioned in a brief abstract ; they have thus covered with a work of uninterrupted investigation, from the sixteenth century up to the present time, almost all the more important regions of Africa which can be found between a line drawn from the mouth of the Congo to that of the Rovuma, and from that of the Cunene to the south of that of the Limpopo. Many explorations, exclusively scientific, more limited, and more delayed in their results, have been and still continue to be carried on.

NYASSALAND.

The next paper was on "Nyassaland and its Commercial Possibilities," by Captain Lugard. The writer said that as a sequel to the cartography of the African continent, came the wish to know something of its peoples, climate, and resources. What we now wanted to know was whether Africa could supply the wants of European civilisation, and take in return the products of our manufactures. Above all, whether it was a suitable field for emigration for Europeans or others. Nyassaland might be defined as the country bounded on the north by Lake Tanganyika and Congo Free State, on the west by Bangweolo, Moero, and Congo Free State, south by Zambesi, east by Shirwa, Nyassa, and Leopold. This country had recently come into public notice—(a) As a centre of the slave trade; (b) of mission work and philanthropic trading efforts; *(c)* of recent fighting of a special character. These points had gained for it a notoriety which might be said to have a practical commercial value. A. Missions afforded a large carrying trade for a trading company. They developed the wants of European goods among the natives, such as calico, soap, beads, brass wire, &c. So also in a less degree did the Arab settlements, and with these too trade should be developed by the offering of better prices for ivory, &c. In return for the articles of European manufacture we should get : 1. From native chiefs.—The entrée into their country, with a view to exploiting the minerals. In payment ivory and other local products. 2. From the Arabs. — Toleration, they being numerically superior. Ivory. 3. From the prople.—Labour and porterage, and minor products. The missions also afforded a strong moral support to a company, and exerted an influence with Government and on public opinion, which would ensure the recognition of the claims of a company. B. The anti-slavery element also exercised a moral weight. The products of the country might be divided into primary, which would pay for their own export ; and secondary, which would bring in some return while the others were being developed, but were mainly useful for local consumption, to save import of European stores, &c.

THE ZAMBESI DELTA.

Mr. A. **Silva White** next read an abstract of a paper by Mr. B. D. J. Rankin on "The Zambesi Delta." The author gave a general description of the Zambesi Delta from the conflux of the Shirs river to the sea. He gave details of the condition of the people; he then indicated the routes used by trade from the interior to the sea, showing how the primitive and inefficient means of communication have tended against the development of trade. He then referred specially to the Inhamissengo, or Slongoni outlet, and the Chindé river—its character and suitability for traffic. He spoke of the physical characteristics of the Chindé mouth; the advantages of using this as the trade outlet, both from a political and commercial point of view, showing how, by using this new outlet for trade, a commercial enterprise formed on the lines of the Niger or Imperial East Africa Congo would have every prospect of success.

The CHAIRMAN then invited discussion on the whole of the African papers, and announced that there would be no sitting of this section to-day.

Mr. MOIR, one of the managers of the African Lakes Company, commented adversely on the action of the Portuguese Government with reference to the Zambesi.

Mr. BATALHA REIS said that he was there not as a Portuguese, but merely as a student of geography, and he would not deal with questions of politics or international law. Capt. Lugard had said that Livingstone had discovered Nyassaland. He (the speaker) had a great admiration for Livingstone, but Nyassaland had been discovered in the 17th century by the Portuguese.

Other gentlemen followed in the discussion.

SECTION F.—ECONOMIC SCIENCE AND STATISTICS.

COMTISM AND ECONOMICS.

The first paper was one by the Rev. W. Cunningham, D.D., &c., on "The Comtist Criticism of Economic Science." In the course of his paper he said:—That political economy has fallen somewhat into discredit in recent years is a fact which must be admitted, and which we shall do well to face. Perhaps it may be partly due to the disputes among leading economists as to the scope of the study; each professes to provide the genuine article, and issues warnings against the exponents of science falsely so called. To my mind, each of the modes of treatment which opponents advocate has a real place in the thorough investigation of economic phenomena. The mere fact that different teachers have adopted such different standpoints only serves to show us the vast range of the subject, when once we come to feel that the different modes of treatment and statement do not necessarily conflict, but may really serve to supplement one another. Human beings are forced to devote conscious efforts to the maintenance and perpetuation of human life; food, clothing, and shelter all subserve this final end, and the conscious efforts for this end which have been made by human beings, under different physical conditions, and in different stages of culture, supply the phenomena which the economist has to investigate. In attempting to indicate a principle of arrangement by which this vast mass of information may be tentatively grouped for our present purpose, I must consider man, not as an isolated being, but as part of an organised society. We may then note several social groups of different types, each of which has been usually regulated as a whole for economic purposes, and which may therefore be taken as distinct economic organisms—the family, the village community, the city or mediæval towns, and the nation. If we for a moment compare these distinct types of economic organism, we may certainly say that those which are mentioned later are far more effective for their purpose than the earlier ones. The simplest tests of economic efficiency are (1) the amount and character of the building done, since it shows how much social energy can be diverted from supplying immediate wants to the work of providing permanent improvements; (2) the success in securing the necessaries of human life as evidenced by the numbers of the population and the death-rate. Tried by these tests, there can be no question as to the superiority of the larger and more complex organisms.

Even when the earlier types are superseded, they must not be ignored, for they continue to exercise an important influence as survivals within the larger groups. For good, and sometimes for evil, the old social structures are embedded in modern institutions. Whatever economic problem has to be faced in England, in the United States, or in India, or in connexion with their relations to one another, we must take the special sociological conditions into account. But some of them at least have appeared at times to forget it, and we have to thank the Comtist criticism for forcing us to remember that the material truth of economic principles depends on complicated social conditions, and that they have no independent validity. In modern life the individual wishes, not to stand well in his class, but to rise out of his class to a better social grade; and since wealth gives the means of gratifying that ambition, the desire of wealth has become a dominant factor in the minds of most men. Thus the "economic man" is not a constant type, but he is always relative to his social environment, both as concerns his habits and his ambitions. The changes in the subject matter of economic investigation, as the more effective organisms superseded others, have been necessarily followed by changes in economic terminology and in economic conceptions. Men have found better means of supplying their wants, partly by mechanical inventions and physical discoveries, partly by introducing better forms of the combination and division of labour. Not only is the modern economic organism most effective, and therefore best worth attention, but it is most complicated and gives us the best opportunity of discriminating different functions, and even by means of statistics of measuring our results with some degree of precision. While we may hold with Comte that the underlying sociological conditions are of the first importance in discussing any economic problem, we may also hold that clear conceptions and accurate analysis are necessary too; and may feel that Malthus, and Ricardo, and Jevons have made contributions to the progress of economic knowledge which are of the first importance, and which we should be foolish to slight. There is another dictum of Comte's to which I must allude. Comte denied to political economy an independent place in the hierarchy of science. This is a hard saying, especially here, since the frequenters of Section F are always nervously anxious to maintain that their science is as good a science as any other, and better too. But, after all, Comte never disparaged the importance of the economic and industrial analysis of society: his dictum referred to his own classification of the principal departments of knowledge. Other branches of learning share a similar fate. Economists have not always recognised the great importance and difficulty of the work of description; it is specially requisite in order that we may pay proper attention to the earlier economic organisms which are found among primitive peoples, or estimate their actual importance so far as they survive among ourselves. It is in this way that account may be taken—and the more methodically the better—of the sociological considerations which underlie any economic problem. The explanation of observed facts must be a matter of great difficulty; they never speak for themselves. We must interpret them, and the economic facts of the past can only be interpreted in the light of the moral and intellectual conditions of life in the past, not by the mere intuitions of an intelligence formed by a nineteenth-century education. But for the explanation of facts in mordern times we do possess such a method; the process of explaining the facts of modern economic life can be carried farther by the use of an hypothesis. In our complicated society we are able to isolate certain phenomena artifically so as to examine the causes which are at work. With this view we may assume the existence of perfectly free competition, and trace out what tends to happen in some particular case on this supposition. This is the form which our *investigations* must necessarily take; but it is one which may be discarded as soon as we have reached definite *results in regard to actual society*. Perhaps one might summarise this criticism of Comte's attitude towards economic science by quoting a favourite phrase of Professor Maurice's, and saying that he was right in what he asserted and wrong in what he denied. If we cherish a hope for the further progress of special science, and especially for advance in economic study, we shall wish to investigate the whole range of economic phenomena, and to attach full importance to the sociological conditions which underlie them; but we shall also welcome additional truth, when embodied in better definitions, as an improvement in our instruments for investigating the phenomena of modern life."

In the discussion which ensued on the paper, Mr. R. H. Inglis Palgrave, Prof. Sidgwick, Mr. J. B. Martin, Prof. Geddes, Prof. Bastable, Mr. D. G. Hoey, and others took part. Dr. Cunningham replied on the discussion.

OUR COAL RESOURCES.

Upon resuming after luncheon a paper was submitted by Professor **Edw. Hull** on "The State of our Coal Resources." In the course of his remarks the author said he regarded the meeting at Newcastle as a fitting opportunity for reviewing the prospects of our coal supply — as this question formed the principal subject of the address of Lord Armstrong at the last meeting of the Association at Newcastle in 1863; and since that time the output of coal from British mines had been proceeding with accelerated velocity, though subject to periodical fluctuations. A diagram had been prepared and was exhibited to show by a series of co-ordinates the rate of production from the commencement of the century. At this date the output of coal probably did not exceed 10,000,000 tons, a very large proportion of which was drawn from the Newcastle district. In the year 1830 the quantity raised in the British Islands was about 29,000,000 tons; in 1860 it had reached 80,042,698; and in 1888 the quantity had reached about 170,000,000 tons, as shown by the returns issued by the Board of Trade. There was reason for believing that between the beginning of the century and the year 1875 the output of coal had more than doubled itself for each successive quarter of a century. Since the year 1860, in which the author had estimated that sufficient coal existed to a limiting depth of 4,000 feet to last, at *the rate of production for that year*, for one thousand years; the available quantity of coal had been reduced by 3,650,000,000 tons; but this amount, great as it was, had not very materially affected our coal resources. The relation between coal-production and the development of the iron-trade since the discovery of the iron-stone deposits of the North Riding of Yorkshire, and the richer hæmatites of North Lancashire and Cumberland, was then considered; and the different coalfields of the British Isles were passed in review in order to show those which are in a progressive condition and which are stationary or retrogressive. The author concluded his subject by expressing an opinion that, while the enormous output of coal during the past few years had not actually crippled our resources, a general rise in the value of coal must ensue in the near future, owing to the greater depth at which the mines will have to be worked and the increased cost of coal-mining. Reference was then made to the great expansion of coal-mining in America, as illustrated diagrammatically, and the author agreed with the late Professor Jevons that future British manufacturers must not expect to derive any help from the import of coal from the United States when coal shall have become dear or scarce at home. Referring especially to the Northumberland and Durham coal-field, Professor Hull said there was no sign of its falling off, despite the length of time it had been worked. He calculated that the supply of this field, at the present rate of consumption, would last 300 years.

Mr. **Stephen Bourne** said there were two or three points which he thought ought to be emphasised. One point was the necessity of the economical use of the gifts of Providence, and thus to avoid the waste of our supply of commodities. He confessed he did not share the views concerning our position if our coal supplies failed in any way, nor did he advocate the restriction of its use if that use were a practical one. It seemed to him that the process of discovery was opening out in different parts of the world coal supplies. He might instance Canada in this respect. This coal supply would not be of much use to us here, but at any rate it would be the means of economising our own supply. He pointed out that we exported something like 20,000,000 tons per annum. Some people said this was waste, and that we had no right to supply our rivals in trade with coal. The truth was that a large proportion of the coal exported was not exported for use by our rivals, but for the use of our own steamers which were engaged in the carrying trade of the world. Having in view the prospect of a speedy transmission of mails and goods through Canada, and so establishing communication with the Eastern Hemisphere, the discovery of coal in Canada would very materially lessen the quantity of coal sent out to mail and other steamers. Then there had been the discovery of immense fields of petroleum. Although there was some difficulty in adapting petroleum to some of the uses of coal, there could be no dispute that this supply had lessened the strain on coal for lighting purposes, and there was every reason to believe that before long it would be adopted to other uses. Again, they must look at the great use of electric light. At present, it was true, that electric light was generated by coal, but water power and other means might be adopted to make electric light supply the place of coal. It was necessary that we should be careful in that which we used, but he was against our begrudging or stinting ourselves by laying up these stores which might never be called into use.

Mr. G. W. **Hastings**, M.P., said there was one great lesson which political economists might learn from the history, during recent years, of coal production. Prof. Hull had pointed out with great truth the unfortunate circumstances which in some cases had characterised the coal production during recent years. It was an industry which so far as the capitalists were concerned, had been in some cases non-paying. In South Staffordshire and East Worcestershire, during the last few months, the profit had been exceedingly small. Some people who dealt with economic science would have said, had such a state of things occurred in some industries, that it was owing to the want of protective duties. (Hear, hear.) When agriculture or the silk industry of Coventry did not pay they were told, "Oh, this is your free trade. If you only kept up a wholesome protective system, as in the United States, you would have good return for capital and labour." Now he wished to point out that coal was one of the few articles in this country, concerning which there had never been any question with regard to foreign competition. It was this country which supplied other countries with coal. And therefore if the arguments of those who were so convinced that it was foreign competition which had reduced remuneration in other industries had been correct, they might have expected that coal, which needed no protection, would always have been making handsome profits. How was it that an industry which had never been interfered with by foreign protection, had been one of the least paying industries in the past? He thought that was a question which ought to be put to free trade gentlemen. It seemed to him that in all probability, if the present return of prosperity continued, and if the price of coal continued to rise there would be a diminution in the quantity of our output of coal. He already saw some signs of this so far as South Staffordshire and East Worcestershire were concerned. As the price of coal went up the colliers demanded, and properly demanded an increase of wages. In the coalfield mentioned the owners found that the recent increase in wages had considerably diminished their output.

Mr. **Stephen Bourne** pointed out that coal was used in the production of articles which competed with British manufactures, so it scarcely could be said that the exportation of coal did not influence the sale of our goods.

Mr. **John Marley** directed Professor Hull's attention to the fact that, thirty years ago, the coal required for the manufacture of a ton of pig iron was double the quantity now required. Steel also required only about half the number of tons of coal for each ton manufactured. This was an element to be taken into consideration in future.

Professor **Hull**, replying on the discussion, said petroleum was not likely to cause much difference in the demand for coal in this country. He concurred with Mr. Hastings that foreign competition had nothing to do with the question of the price of coal. He looked upon low prices as due to over-production. More pits than were necessary were sunk after the last period of revival.

OUR WEST AFRICAN POSSESSIONS.

Mr. H. R. **Fox Bourne** submitted a paper on "Our West African Possessions: their economic opportunities, and how they are abused and neglected." In the course of his paper he said: Our West African possessions are not properly colonies. Though we have acquired considerable territory and extensive sea-frontage at the Gambia, Sierra Leone, the Gold Coast, Lagos, and the Niger Protectorate, these places are not adapted for European settlement, and almost their only political value to us is in connexion with commerce. We should so hold them, if we choose to hold them at all, as to develop honourable trade with the natives near the coast, and also with the superior and far more numerous races that inhabit the tablelands in the interior, where a genial climate, an immense area of fertile soil, and a profusion of mineral wealth, afford facilities for a vast development of commerce, which should be beneficial alike to the natives and to the Europeans who deal with them. The tendency of our present policy is to leave this work to be done, if at all, by the French, who, in extending their influence along the course of the Senegal and among the communities beyond, are acquiring a position which may prove extremely detrimental to us in our dealings with the tribes near the coast. In the meanwhile, by our treatment of these latter tribes, we are doing yet more to injure our prospects and spoil our opportunities. Such harsh and frivolous meddling with the natives as is generally the rule with our officials on the West African coast, though ostensibly and primarily adopted with a view to protecting and extending our trade, is really most prejudicial to it. As quite recently examples of this mischievous and discreditable policy, may be adduced the expedition despatched from Sierra Leone this year against the Chief Markiah in the Sulymah district, last year's crusade against the Tavieves at the Gold Coast, and the recent overthrow and deportation of King Ja Ja in the Niger Protectorate. Our policy should be to befriend, not to bully, the natives; to make alliances with their chiefs, not wars against them. As Lord Brassey has said, "We must co-operate with the native populations in the development of their resources, we must help them to accumulate wealth, or they cannot purchase our goods."

Governor **Maloney**, of Lagos, protested against any conclusion which endeavoured to show that there had not been every attempt made to conciliate the natives. In no part of her Majesty's domains were the inhabitants better treated than in the colony he represented, and the natives were perfectly satisfied with what had been done and was being done for them; they wished for nothing more. He had no reason to believe that the same consideration was not extended towards her Majesty's subjects in other parts of her domains.

Mr. **Fox Bourne** said Lagos had the advantage of having a Government who had carried out the policy he had attempted to sketch in his paper.

SECTION G.—MECHANICAL SCIENCE.

A STEADY PLATFORM AT SEA.

Mr. **Beauchamp Tower** described an apparatus for providing a steady platform at sea for guns, search lights, telescopes, &c. The author described an apparatus large enough to carry a 3-pounder gun, which he has constructed and mounted on his 25-ton steam yacht, and which keeps perfectly steady even when the vssel is rolling and pitching violently. The apparatus consists of the platform, which is the part to be kept steady, and which is hung in gymbals. The steadying forces are applied by four cylinders attached to the platform, which push by means of rams at four external points. The action of these cylinders is controlled by a wheel revolving rapidly in a horizontal plane on a ball and socket bearing attached to and between the four cylinders. Water at 100lbs. pressure is pumped by a pumping-engine through the gymbals, which are made hollow for the purpose, and thence through a pipe on the platform through the ball and socket bearing of the wheel, which has a passage through it for the water to pass to a cavity in the centre of the wheel; from this cavity some of the water passes to tangential jets, which cause the wheel to revolve by their reaction at about 1,500 revolutions per minute. The remainder of the water issues from an axial jet which projects upwards from the wheel, and has opposite to it, and at a distance equal to about the jet's diameter, four ports grouped close together, and each connected by a passage to one of the four cylinders. The wheel, being hung a small distance above its centre of gravity, settles itself down to revolve in a truly horizontal plane, and to throw a truly vertical jet out of the axial jet-nozzle. This jet striking on the four posts causes a water pressure in the four cylinders, which pressure is equal in all the cylinders if the jet is truly concentric with the four posts; but, if it is not, one of the ports receives more of the jet than the others, and the cylinder connected to it has a greater pressure, and consequently pushes harder than the others, and pushes the platform over till the ports and axial jet are concentric. The axial jet thus forcibly compels the platform to be co-axial with it. The object and advantage of this arrangement is, that while the wheel acts powerfully on the platform it suffers no reaction on itself, and no matter what disturbing forces are brought to bear on the platform none of them can affect the wheel. The author has experimented with this apparatus at sea for a considerable time, and has overcome the usual practical difficulties and brought the apparatus to a high state of perfection. The apparatus is also applicable for swinging cabins, and experience with it seems to justify the belief that the abolition of the angular movement alone would prove a great mitigation of sea-sickness. The sensation of sitting calmly at one's ease, and seeing the ship rolling about and everyone else holding on was a very novel one. The apparatus might be applied to mount a chair, in which an invalid suffering from sea-sickness might sit.

Captain **Noble**, of the Elswick Works, Newcastle, asked what the weight of the apparatus would be that would take a 6-pounder.

Mr. **Tower** said he thought it would be about one and a half times the weight of the gun.

Capt. **Noble** asked Mr. Tower if he had formed any idea how far he could carry the system in applying it to larger guns. Would the ratio of weight be increased?

Mr. **Tower** said he did not think that the ratio of weight would be increased. His own view about the practicability of applying it to large guns was that it would better be used as a director to fire the guns. It would be easy to construct an apparatus so that electric contact might be made when the large gun came parallel with the side or with the machine gun on the platform. At present, he would not propose to use it for anything larger than, say, a 6-pounder quick-firing gun. It might in course of development be applied to larger guns. But especially for quick-firing guns it was useful, and for mounting electric search lights. The Admiralty were going to try it for mounting electric search lights and machine guns very shortly.

Capt. **Noble** said he had had the advantage of seeing the apparatus under Mr. Tower's explanation, and he must say that, so far as he could see, he had succeeded perfectly in what he proposed. It was very difficult to exaggerate the ability which had been shown in working it out. As far as regarded its application to ships of war, that was a question that would have to be left entirely to those who had to use the guns. Mr. Tower had succeeded in overcoming the difficulties due to the unstable platform, but it was, of course, impossible to overcome that which was due to the verticle rise and fall, and the motion which came from the send of the sea. With regard to small boats, for which it would be principally used, there was the disadvantage of the additional weight.

The question was whether it would be better in war ships to adopt this system, or to have two guns and let them take their chance of hitting. It was very desirable that such an experiment should be made, and he was glad to know that the Admiralty were going to do so. From his experience of Spithead, he believed it would be easy to have two launches, one with each system, and to compare the result. If Mr. Tower's system gave better results, the additional weight would be no serious disadvantage, and the launches might be made a little larger to accommodate the extra weight. The arrangement would enable ships to dispense with a number of guns, but he believed with a distinguished naval officer that in naval combats of the future the vessel that got in its second broadside first would be the victor, so that it was of considerable importance to have the broadside as powerful as possible. Still, there was a great advantage in having a gun which could discharge from a stable platform a large number of rounds in a short space of time. This would counterbalance any little disadvantage from the extra weight of the mountings.

Mr. Tower read an extract from the report of the committee on the naval manœuvres last year, in which it was pointed out that certain guns in a heavy sea were practically useless.

VIBRATIONS IN RAILWAY TRAINS.

Professor Milne, Professor of Geology in the Imperial College of Engineering, Tokio, Japan, described his instrument for recording the vibrations of trains.

The President thought the instrument would be useful for enabling traffic managers to know what their trains were doing.

Professor H. S. Hele Shaw, Liverpool, spoke of the great advance in and utility of self-recording machines.

Mr. W. W. Beaumont, London, asked if the instrument would show definitely where any defect in a line occurred.

The President asked if the instrument would show where the automatic brakes were put on throughout the train.

Prof. Milne: Yes, most distinctly. In regard to defects in lines, he was inclined to think that the instrument would record accurately where a defect occurred. He instanced a case where the yielding of a girder in a bridge was discovered by means of the instrument.

The President said that, in the event of an accident, the machine would show the exact time when the brakes were put on and taken off, and would set at rest a great deal of conflicting evidence which arose in such cases.

BOTTLE-MAKING BY MACHINERY.

Mr. H. M. Ashley, Ferrybridge, read a paper on the manufacture of bottles by machinery. He explained the principles on which the system was based. In the beginning, he reviewed the old processes of bottle-making, describing briefly gathering, marvering, blowing the bulb, completing the shape of the parison, blowing the bottle in the mould, wetting off, warming in of the neck, lapping of the ring, and finishing the ring. Explaining the new processes, he illustrated the parison mould, the ring mould, punch, paddle, bottle mould, and air supply. Glass was in its normal condition a very slow conductor of heat, but became, under certain conditions, a very rapid conductor of heat. Glass in its transition from a molten to a solid condition became perfectly plastic. At a temperature of 300 degs. glass could be cast in moulds like metals. At 2,000 deg. it was so perfectly plastic that it could be moulded as an artist would mould a piece of clay, provided that the moulding tool was hot enough and suitably lubricated. At 1,000 degs., it was so elastic as to be almost undamageable. All these changes would take place in about five seconds of time. His invention was based on these principles. The bottle made by his principle was perfectly homogeneous. The ring, neck, body, and bottom were all absolutely one. He exhibited examples showing the manufacture of glass bottles in the various stages. Eight of the machine-made bottles, taken from the usual stock, had been tested internally by hydraulic pressure to 400lbs. per square inch, and none had broken.

Mr. A. Carpmeal, London, said Mr. Ashley belonged to that class of men who were likely to revolutionise a trade, from the very fact that, when they began to investigate, they knew nothing about it. (Laughter.) Any bottle maker would have told him that he was mad to begin his bottle where he ought to have left off. But that was just what Mr. Ashley had done, and he had been very successful.

Mr. Hastings, M.P., said he had seen the machine at work. He watched it for twenty minutes, with his watch in his hand, and during that time the machine unfailingly turned out bottles at the rate of three in every minute. The invention was important in a sanitary way. It was well known that the occupation of a glass-blower was one of the most life-destroying of our industrial occupations. The average of life was something like thirty years with those who were employed in blowing bottles. This machine would fully do away with the unsanitary part of the occupation, and there was no reason why the men who were employed in working this mechanism should not be as long-lived as those around them. He felt that, if this machine could be consummated, there would have been one more blow struck in favour of the health of the country. That was the original reason why he took such an interest in Mr. Ashley's invention.

PEAT FIBRE IN PAPER-MAKING.

A paper was read by Mr. J. A. Loudon, of Newcastle, on the utility of employing peat fibre in the making of brown paper, wrappers, millboard, &c. The object of the writer of this paper was to show the practical uses of suitable peat fibre as a raw material in the manufacture of brown paper, wrappers, and millboards, and its economical use in many ways. The machine the writer uses for treating this material is a "willow" or "devil," consisting of one drum 3ft. diameter by 12in. on the face. This drum is covered with a concave. Both the drum and concave are furnished with cone-shaped teeth, so that the fibre cannot adhere to the teeth; but the principal advantage is that the teeth can be set to fibreise to any degree of fineness. Owing to the speed at which it runs, no fibre hangs about the machine, and it will fibreise or tear the peat fibre in a wet or dry state. The materials hitherto used consisted of rags, ropes, esparto grass, &c. The peat was obtained in large areas of waste land, where the vegetation had been carbonising for centuries. The peat was cut into square bricks, which were placed in open stacks, and left to partially dry. When still in a state of semi-dampness, the peat bricks were put into the "devil" and teased into beautifully soft and delicate shreds. For paper-making purposes, the fibre was sorted by hand, only the finest shreds being selected. It was estimated that the cost of this material was 40 per cent. less than the old materials, and that the cost of production of paper could be lessened by £2 per ton. Peat fibre was also used in upholstering, caulking, as a deodoriser, as mould for horticultural purposes, &c. The removal of the peat also rendered waste land capable of producing crops. There were in Ireland about 3,000,000 acres of bogland, and the removal of the peat would give employment to numbers of men, and would rescue the waste land for cultivation.

The President asked if the peat fibre had any strength in itself.

Mr. Loudon said it had, when chemically treated.

Lord Rosse said he was very glad to hear that peat fibre had been used in the way described. There were extensive bog areas in Ireland, but it was principally inland, and the cost of bringing the peat to the sea coast was as great as bringing it from Hamburg or some other of the German ports. He noticed that some newspapers tore readily, and he thought this was perhaps attributable to the use of peat fibre or some other of the modern substitutes. But if the fibre was strong enough for its purpose, that was all that was required.

The President said his recollection of Irish peat was to the effect that it was not really so fibrous as the specimens shown by Mr. Loudon.

Mr. D. Sherlock, Tullamore, said that there were great quantities of peat in Ireland very near the surface.

A Member: Is it possible to make a fairly good white paper?

Mr. Loudon: No.

Mr. W. **Bayley-Marshall** asked what was the cost of the peat as compared with wood pulp, which was used very largely.

Mr. **Loudon** said the saving, compared with wood pulp, would be about 50 per cent. The chemical treatment which the fibre underwent made it stronger than wood pulp. The fibre was already used in about five mills. One mill on the Tyne used twenty tons a week, and another mill in the south used it very extensively, and it was gradually but surely taking the place of old bagging, which was injurious to workpeople.

The **President** said it was a novel manufacture that had been introduced to them for the first time, and it was very interesting and very useful.

HYDRAULIC SIGNALLING.

Mr. C. E. **Carr** read a paper on "Hydraulic Railway Signalling," in which he described a system that would lessen the labour in signal cabins, accelerate the lowering of signals, and eliminate certain costly and perishable parts of the mechanism.

Mr. W. **Shelford**, Kensington, said that in railway signalling England was pre-eminent. Americans were copying our system. It had now come to this point, that it was now a question of actual labour. If any one could see the signal cabins on the Metropolitan District Railway, and see the amount of labour a man has to do in order that the public might travel safely along the line, he would understand that it was merely a question of hard work, and the whole occupation and thought of the man were given to seeing how he could do that manual labour. Such a contrivance was, therefore, of great importance. He believed, however, that Mr. Carr had been forestalled, for a Genoese engineer had a hydraulic system in the Paris Exhibition, and the best signal-makers in this country held a high opinion of it.

Mr. **Carr**, in answer to a question, said that, in a climate like England, he would not use water in winter, but would use a fluid that would resist the action of frost.

SECTION H.—ANTHROPOLOGY.

EARLY EGYPTIAN ART.

In the absence of the Rev. J. Wilson, M.A., Mr. G. W. **Bloxam** (one or the secretaries) read an abstract of a paper on "Hypothesis of a European Origin of Early Egyptian Art." The paper stated that Egyptian art had reached a high degree of perfection at the beginning of the First Empire. In Egypt, as elsewhere, art was not full-grown at birth. Centuries, perhaps millenniums, of previous progress were necessary ere statues such as that of the cross-legged Scribe in the Bulak Museum could have been executed. Where was art thus gradually matured in the centuries before Menes? Not necessarily in Egypt, since in early times the nation was composite. Can archæology point to any palæolithic race endowed with the promise of high artistic skill? Only one, viz., the so-called Cro-Magnon race of South-Western France. MM. Zabovowski and Broca quoted as to the importance of the traces of incipient art in the hands of this race. Their drawings on plates of ivory, bone, &c., of the mammoth, as well as the reindeer and antelope, are sufficient proofs of the vast antiquity of that race, which lived in the transition age between the period of the mammoth and of the reindeer. What connexion can be shown to have existed between this race and early Egypt? Ethnologists, such as Virchow, Sayce, Maspero, agree that a leading element in the old Egyptian Empire was a white race, and some recent Egyptologists refer this white element to the Mediterranean race which belonged to the stock called by French archæologists the Cro-Magnon race. Comparison between the Mediterranean or Cro-Magnon race and the Egyptians of the First Empire as to physical characteristics. Extension of the later representatives of the Cro-Magnon race southwards to the Mediterranen islands, the Canaries, and North Africa, owing to geological and climatic changes. The transit to Africa would be easy at a period when North-Western Africa was still joined with Spain. This southward migration—at least as to its later waves—coincided with the incoming of a new race, the dolmen-builders, who passing, at least immediately, from Northern Europe, became mixed with the Cro-Magnon race in France and Spain, and passed into North Africa, where they were represented by the white *Thakennu* of the Egyptian sculptures and by the modern Kabyles of Algeria. The old artistic talent of the Cro-Magnon race nowhere reappeared (except in Egypt), because the cultivation of art requires certain favouring condition which were found in perfection in Egypt. As to whether the European invasion of North Africa took place at a period considerably earlier than the dawn of the First Empire [evidences adduced]. What evidence is there that this invading European race overran Egypt? Besides the traces of a common race-type between them and the earliest Egyptians, we have the fact of invasions of Egypt by branches of the Mediterranean race within the historic period and facts indicating that in prehistoric times this race had traversed the Nile Valley. Further, the political state of Egypt before Menes, as indicated by tradition, agrees with our hypothesis of a warlike northern race ruling a subject population. Next inquire how far the earliest Egyptian architecture agrees in type with that of the prehistoric European invaders. Can the former be conceived as identical with the latter, though at a higher stage of development? Character of the North African megalithic structures compared with that of the earliest Egyptian buildings. Governing ideas common to the sepulchral architecture of prehistoric Western Europe and of early Egypt. Method of protecting the abode of the dead from violation. The tomb considered as the dwelling-place of the dead, or his "double." Necessity of distinguishing the rank of the dead by the size of his sepulchre. Summary of points of resemblance between the pyramids and the great chambered tumuli of Europe. Analogies between early Egypt and prehistoric Europe in regard to other arts and customs. One reason makes it probable that the less civilised northern invaders of Egypt, while adopting the civilisation of that country, would conserve their own form of sepulchral architecture. What must we make of certain curious analogies between the agriculture of neolithic Europe and of early Egypt? Analogy between curious sculptured figures in the caves of Marne with certain Egyptian divinities. The absence of linguistic affinity between Egypt and prehistoric Europe does not militate against our hypothesis.

The **President** said the subject was one which would allow of a great deal of discussion, but they must feel the absence of the author of the paper, who would have gone into the subject more thoroughly than had been laid before them in the abstract. He might say that all, whether members or associates, were requested to give their views on any paper which might be submitted, if they had anything to say which would be of value in connexion with the discussion.

Prof. **Boyd Dawkins**, in the course of a few remarks, said he felt some difficulty in saying anything on the extraordinary view placed before them in the abstract. It was extremely difficult to deal with a question of that sort, unless they had the author before them to give his reasons, and to give them the benefit of what might be a sort of cross-examination. He had listened, but without success, for the slightest shred of evidence in support of the European origin of early Egyptian art. With regard to the special points in the paper—the first was that the more ancient of the Egyptians were the lineal descendants of that unknown race of mankind that lived in the lone caverns, and was contemporary with the mammoth and with other extinct creatures over Europe. He freely joined issue with him on that point. He, however, failed to recognise any trace between the art of the cave men and the early Egyptian art.

Canon **Isaac Taylor** also spoke on the subject.

AFRICAN MUSIC.

An interesting paper on "African Airs and Musical Instruments" was read by Mr. H. E. Moloney, C.M.G., Governor of Lagos, West Africa. The author pointed out that in most of the works of travellers in West Africa they found references to the musical capabilities of its peoples. For such airs as they found set to music, the different mission bodies who laboured there must have most credit, as they had also for their invaluable work, represented by the committal to writing, and the various vernaculars spoken along that coast. Their instruments included the big and small drums, harp, guitar (four kinds), violin, harmonicon, and flute. The oro drums are used to proclaim meetings of the Oro Society convened for the trial of public offenders, &c. When "Oro is out," all women, under pain of death, were obliged to remain shut up in their homes. The greatest reverence was extended to this instrument. The intonation of the Mohammedan call to prayer was now heard in most of the important centres of West Africa. The speaker gathered from a musical and enlightened Zaraba gentleman that the native character partook often of a nature spiteful and revengeful on the occasions of trivial offence, which had necessitated at times the interference of the Government as to grants of permission to sing or play in public. The author distributed the airs geographically as follows: A, Gambia; B, Ewe or Dahomey; C, Yoruba; and D, Houssa. In the first division specimens were given of Bambara, Mandingo, and Volof melodies, while Popo and Dahomey airs illustrated section B. The Yoruba division included Lagos, Ibadan, and other airs, and reference was made to several Houssa melodies. These countries were topographically described, and brief reference was made to their musical instruments and to the native minstrels. The paper concluded with an explanation of what is known as the "drum-language."

M. Paul B. du Chaillu said he had heard the air "Call to Prayer" at the Equator, and Canon Taylor thought there was a great similarity in the air to the call to prayer of the Mohammedans.

Mr. Carl Lumholtz, member of the Royal Academy of Science. Christiania, Norway, stated the air was very like the air sung by the Queenslanders. The natives of Australia. he said, had no musical instruments except a piece of hard wood, which was beaten by another stick. Mr. Lumholtz then sang the air he spoke of, and imitated the native instrument by beating two sticks. The effort was loudly applauded.

Mr. Chas. Niel also offered a few remarks, and a letter was read by the President from Mr. J. Batalha-Reis, F.R.G.S., Portuguese Consul, of Newcastle, who stated that the Lisbon Geographical Society had for some time been collecting the popular airs of the African population, and had just published a portion of those of the Cape de Verde Islands. Many of these airs were evidently products of the influence of Portuguese popular music, especially of the songs which the Portuguese called "Fados."

Governor Moloney said he had collected the airs to show the rapid spread of Mohammedanism from east to west.

THE VIKINGS.

M. Paul B. Du Chaillu read an interesting paper on "The Vikings, the Direct Ancestors of the English-speaking Nations." The author described the early civilisation and antiquities of the North-men, and dwelt upon the beauty of their ornaments and weapons, and also upon the similarity of Scandinavian and English ornaments belonging to the early iron age, and the love of the Northern people for the sea. He spoke of the three maritime tribes of the North, according to the Romans, and of the fleets of the Sueones in the time of Tacitus; of the expeditions of the so-called Saxons and Franks, and of the home of these tribes; of the proofs from antiquities found in the North of the commerce of the North-men with the Roman Empire and with Greece, and also pointed out that the tribes of Germania were not a seafaring people, and were uncivilised, according to Roman writers. He gave an account of the probable origin of the names "Saxon" and "Frank," and spoke of the early settlements in Britain by the North-men during the Roman occupation, and of how the name of England might have been given to part of Britain. He alluded to the different countries of the Jutes, and how the language of the North and that of England was similar in early times, and that England was always called by the North-men one of the Northern lands, and of the early Northern kings who claimed to own part of England. He mentioned the English and Frankish chronicles, in which the Sueones, Danes, and North-men are described, and that neither Saxons nor Franks were a seafaing people either at the time of Charlemagne or at any earier period, and he dwelt on the mythical settlement of Britain by Hengist and Horsa, given by the English chronicles, which is quite contrary to the Roman records, Sagas, and archæology, and concluded by showing that the North-men, or Vikings, were the direct ancestors of the English people.

Dr. Evans pointed out that in a large proportion of the better inhabitants of the British Isles Scandinavian members might be traced. The Scandinavian language sounded very like English. There were, however, a number of historical facts which appeared illsuited to fit in with the views advocated by M. Chaillu.

Mr. H. H. Howorth, M.P., objected to the title of "Viking" of the paper. The word "Viking" was understood by authorities—by Professors Storm and Strenstrop—as limited to the Norse pirates of the 9th and succeeding centuries, and was never applied to the earlier inhabitants of Scandinavia. The Viking art and Viking literature, so far as they could make them out, were very largely of Western origin. The Viking swords had the names of Englishmen upon them, and Vigfasson had proved that the Sagas were inspired by the contact of the Norsemen with the Celtic races. Going back, he said the archæology of the Saxons and Angles was entirely different from that of the contemporary Scandinavian art, and agreed completely with that of the other Teutonic invaders of the Roman Empire, from Italy to Yorkshire. If they tested the problem by place names, they found that the Anglican and Saxon settlements corresponded in nomenclature with the country about the Elbe and Saxony, and had nothing to do with that of Scandinavia. On every ground, therefore, it seemed clear that it was a retrograde view to identify the Saxons and Angles with the population of Scandinavia in the 4th century. It might be that, like the other Teutonic tribes which invaded the Roman Empire, the Angles and Saxons were led by a sacred race which had its home in Scandinavia, but to say this of the great mass of the people must revert to the science of 40 years ago, which ought now to be obsolete. (Applause.)

Dr. Hodgkin alluded to the words Elswick and Elwick in the district of Newcastle, which they had been taught marked Danish settlements. There could be no doubt that they were anxious to have a claim on the Scandinavians. As to why the Saxons came over, his pet theory was that it was the invasion of Attena, the Hun, that sent our Saxon forefathers over the sea to seek a home in this England of ours.

Canon Isaac Taylor also offered a few remarks.

Professor Dawkins said the point placed before them was whether there was sufficient evidence laid before them in favour of the direct descent of the English-speaking people from the Vikings. If they were to accept the evidence so ably put before them by modern historians, and the results of researches into ruins or into archæological matters, they had not a difficult matter to decide. It seemed they had no evidence in support of the position taken up by M. Chaillu. He (the speaker) had given some study to the subject, and he thought M. Chaillu's views untenable. He thought there was a misapplication of the word "Viking." If M. Chaillu applied the word to the people who preceded the Vikings so many centuries, he did not think the ground of difference between them would be so great. He felt indebted to the author for the paper, but at the same time he must utter his humble protest against it. (Applause.)

Dr. Jevons said, speaking as a philological student, he thought there was no evidence in support of M. Chaillu's contention.

The President thought M. Chaillu had taken up too exclusive a position in the matter. If he had taken up the position that there was a large Scandinavian element in the English speaking people, there would have been less discord or difference of opinion. (Hear, hear.)

M. CHAILLU, in reply, said he had laid before them the study of eight years, and many a day he had spent from 16 to 18 hours in the research. Having rebutted several of the arguments brought forward by speakers against his views, M. Chaillu somewhat excitedly concluded his remarks, and said "Patriotism is a splendid thing, but let us have truth. I belong to the other side of the water—America, so they won't accuse me of being one-sided there."

THE ORIGIN OF THE ARYANS, ETC.

Canon TAYLOR, LL.D., read a paper on "Further researches as to the origin of the Aryans," and followed with a second paper on "The ethnological value of the Beech."—In the discussion which followed Prof. Dankins, General Rivers, Dr. Jevons, Dr. Isaac Ashe, and Mr. H. H. Howarth, M.P. took part.

PROPERTY IN TREES.

Mr. HYDE CLARKE read a paper on "The Right of Property in Trees on another's Land, as an origin of Rights of Property." The author stated that his attention was first called to the subject, as a land-judge or commissioner in Asia Minor, in 1862, in granting compensation for olive trees belonging to one or more individuals on the fields of others, and for honey trees or hoards of wild honey in State or Communal forests. In 1888 Rev. Dr. Codrington read a paper at the British Association, and afterwards at the Anthropological Institute, which gave information as to the existence of a like system in Melanesia. The author thereupon proceeded to make further inquiries, and found evidence as to its existence in Borneo, with regard to Tapaag or honey trees, and in Chota Nagpore (and probably elsewhere in India) as to the Mhowa, a tree furnishing food, spirit, oil, &c. In China a lessee has the right to bamboo, &c., grown by him. The practice in the Turkish Empire he found extended into the European provinces, as applied to plum-trees in Bosnia. In Ireland it was recognised in the Brehon Laws as an individual property separate from tribal property. Generally speaking, the right does not exist in Europe, as all rights are centred in the owner of the soil. It is probable that the personal right of the first discoverer of honey and similar trees, a right defined by Sir H. S. Maine as dependent on discovery, is to be regarded as the origin of an individual right of property rather than any right in land, which is of no value in a primitive community. Even cultivable land belonged to the community, and was distributed by lot yearly, of which there are modern examples.—A short discussion followed.

NOMAD TRIBES OF ASIA MINOR.

Mr. BENT read the report of the committee, consisting of Dr. Garson, Mr. Bent (sec.), Mr. Pengelly, Mr. Rudler, Mr. Bloxham, and Mr. J. Stuart Glennie, appointed to investigate the habits and customs and physical characteristics of the nomad tribes of Asia Minor, and to excavate on sites of ancient occupation.

HARDENING AND TEMPERING OF STEEL.

LECTURE BY MR. ROBERTS-AUSTEN.

At night, Professor Chandler Roberts-Austen lectured in St. George's Hall, Newcastle, on "The Hardening and Tempering of Steel." There was a very large attendance. The chair was occupied by the President of the British Association (Prof. W. H. Flower); and, in addition to most of the members of the British Association in Newcastle, there were present the Mayor of Newcastle (Mr. Thomas Richardson), Lord Armstrong, Sir Chas. Mark Palmer, Bart., M.P., &c.

The PRESIDENT said: Ladies and gentlemen, it seems quite superfluous on my part to introduce to you any one so well known as Professor Chandler Roberts-Austen. He is, as you probably know, professor of metallurgy at the Royal School of Mines, and is also chemist to her Majesty's Mint. In that capacity he is responsible for the purity and the proper composition of the coins that we use in circulation; and probably there is no one so well acquainted with the properties of metals as he is. He is not going to talk to you about gold or silver, with which he is so familiar, but about another metal in many respects more useful. Without any further introduction I will ask Professor Chandler Roberts-Austen to give you the lecture for which he has prepared this extremely interesting and complete set of diagrams and apparatus. (Cheers.)

Professor ROBERTS-AUSTEN then delivered his lecture. After a tribute to the memory of the late Dr. Percy, who had almost created an English literature of metallurgy, and a reference to the national value of Lord Armstrong's efforts in developing the use of steel, Prof. Austen proceeded to give a brief history of our knowledge of the art of hardening and tempering steel. Hardening, he said, is the result of rapidly cooling a highly heated mass of steel. "Tempering" or softening consists in reheating this hardened steel to a temperature far short of that to which it was raised before hardening. He demonstrated these facts by hardening and tempering three sword blades of the same steel and of excellent quality, showing how greatly the efficiency of the weapons depended on the treatment they received. A sword blade which was overhard snapped under gentle pressure into many fragments, while one which was overtempered could readily be bent by the hands, and remained crooked. Professor Austen stated that such facts were of vital importance to the nation, Mr. Ruskin even having said that iron-working was the only art "of any consequence which we have at present in England," and that in armour plates our courage and endurance were written for ever with an iron pen nor iron parchment." Notwithstanding the great importance of the art of hardening and tempering, the theory of the process was still far from clear, and such knowledge as we possessed had been but slowly gathered. It was shown that in early times great pains were taken to secure what was believed to be a suitable solution for quenching the hot steel, so as to abstract its heat. Othello's sword, Shakespeare said, had the "ice brook's temper," but cold water was far too simple a material for many a 16th century artificer to employ, as was shown by the quaint receipts for hardening steel which had been handed down to us; the operator being directed in a manual published in 1531 to "take snayles and boil them in rain water taken in the two first months of harvest," in which solution if hot steel were plunged it would be very hard, the craftsman being prettily told so late as 1809, that he might "take the root of blue lilies, infuse it in wine, and quench the steel in it, and the steel will be very hard." The belief in such quaint nostrums survived into the present century, and it was pointed out that the early workers were right in attaching great importance to the nature of the fluid in which the steel was quenched, though their theories were wrong, the degree of rapidity with which heat was abstracted from the cooling steel being as important at the present day as ever it was. Professor Austen then traced the history of the theories relative to the internal condition of steel, pointing out that the work of Bergmann, of Upsala, showed, in 1781, that steel differs from iron only by containing 2-10 to 1½ per cent. of carbon. The curious relation between the belief in the existence of phlogiston, and the fight made by the Phlogistic School with that of Lavoisier over the constitution of steel was dealt with at some length, and it was pointed out that the work of Bergmann, though himself a believer in phlogiston, had entirely changed the situation by showing that carbon was the steel-giving element. Clouet did much to prove (1798) that carbon in its diamond form could combine with iron and convert it into steel, a fact which had been confirmed by a working cutler, Mr. H. Pepys, in 1818, and finally by Prof. Austen himself, who, for the purpose of the lecture, had heated diamond and carbon together in vacuo, because in all previous experiments a doubt as to the action of gases contained in the iron had existed. Professor Austen then proceeded to consider the mode of existence of carbon in the steel. He showed at great length that, although carbon in any of its forms, graphite, soot, or diamond, could enter into intimate association with iron, the relations of carbon and iron were really very complex. The researches of Karston, Berthier, and finally, of Sir E. Abel, had shown that in soft steel the carbon exists in the form of a true compound or "carbide" with iron, while in steel which has been hardened by rapid cooling the carbon is "dissolved," and not truly combined; in "tempering," or softening steel, another change in the relation of the carbon and iron being effected, the degree of hardness of the steel depending mainly on the relations subsisting between the carbon and the iron, although the state of the carbon did not explain all the facts of hardening and tempering. The next portion of the subject was one of great difficulty. Prof. Austen gave full reasons for the belief that iron itself can exist in more than one state. For instance, carbon may be equally pure carbon either in the diamond or sooty form; sulphur equally pure sulphur either in a form which is soft and pliable at ordinary temperatures or in the hard yellow form with which we are all familiar with it; the soft passing instantaneously into the hard variety with evolution of heat. In the same way there is strong reason to believe that at a red heat the molecules of iron are really hard. If pure iron be cooled either quickly or slowly, it passes into the soft modification, but if carbon be present, and the metal be quickly cooled, it has no time to pass to the soft modification, the presence of the carbon hindering its passage, and hard steel being the result. Bearing in mind that evolution or absorption of heat is the surest indication of molecular change in the element, Prof. Austen gave experimental evidence of the existence of molecular change in iron. One experiment was very curious. A red hot bar was taken from the furnace gripped only at one end, while a weight was attached to the other. The bar did not bend when being in its hottest state, it might have been expected to be soft, but it fell six inches as soon as the point of molecular weakness came, the iron being comparatively cold. Prof. Austen showed how important the action of small quantities of matter on masses of metal really is, pointing out that this appeared to be a broad principle of nature, one recognised by the alchemists, and still employed by metallurgists, who marvel daily at the extraordinary effect which would be produced in iron by quite small doses of sulphur, phosphorus, chromium, or aluminium. Professor Austen said that he was not afraid of the taunt of Francis Bacon that "sottishly do the chymics appropriate the fancies of poets in the transformation of bodies to the experiments of their furnaces," for although metals could not be transmuted, they could be transformed, by very slight influences, so as to behave, from the point of view of special work demanded from them, either beneficially or prejudicially. He concluded by pointing to the importance of hardening and tempering in relation to all kinds of steel. In the early days when steel was substituted for iron, it was viewed with suspicion, mainly because the fact that iron could exist in two distinct molecular states was ignored. He showed that the material of which the Forth Bridge is made owes its substantiality to the fact while being very strong, it is very soft and ductile, and will not harden energetically. The enormous importance of the substitution of steel for iron was shown by the figures supplied by Mr. Webb, of Crewe, who stated that on the entire system of the London and North-Western Railway eighteen tons of steel disappeared daily by oxidation and wear. With regard to highly carbonised steels, it was shown that a properly tempered die would strike 40,000 coins, while one which had been over-hardened would probably fracture with the first coin it attempted to strike. In conclusion, Prof. Austen said it was strange that so few researches had been devoted to the relations of carbon and iron, and so many to organic chemistry. This arose, he thought, from the belief of chemists and physicists that operations which involved the use of high temperatures were necessarily inaccurate. It could not be that chemists feared to quote Macaulay, that "science would be degraded by being applied to any purpose of vulgar utility," for he trusted that he had shown that, "the empire over matter," which was the object of all research, could be as surely gained in the field of metallurgy as in any other.

Sir **FREDERICK BRAMWELL** moved a vote of thanks to Professor Roberts-Austen for his lecture. They had had a lecture which was most appropriate in that city. The plan of hardening and tempering steel, which metal had within the last quarter of a century been gradually usurping the position that was formerly occupied by wrought iron, had been conducted to very good purpose. When they considered the difference of manufacture, and the difference of product there was between wrought iron made by the puddling process, and then united more or less perfectly by welding, and the steel made by some process involving fusion, and then forged in the ingot state, he thought they would all agree they had now to deal—and their successors would have to deal—with a material which, for almost all engineering purposes, was far and away superior to the wrought iron with which their forefathers had to be content. (Hear, hear.) If this were true of the metal itself—as it certainly was—the question as to the treatment of this most valuable new metal—for new it was—in the wholesale manner in which it was produced and used—the manner in which this new metal should be treated as regarded its hardening and tempering was of the very highest importance. (Hear, hear.) It was true that, except in certain particular manufactures, large masses of steel were not, as a rule, hardened and tempered, but there was one manufacture, and one which was the prominent manufacture of this city—that of artillery—wherein large masses of steel were dealt with to be oil-hardened, as it was called, and afterwards dealt with in the way of annealing, if not in the way of tempering. It was true they succeeded in them, but they succeeded by reason of the experience of the men who had been devoted to the manufacture all their lives, who knew what to do, and knew what would result, but could not tell why it would result; and it was to the labours of men like Professor Roberts-Austen, who endeavoured to investigate the cause of these effects obtained, that they looked forward to the certainty in manufacture which at present did not exist, our dependence at the present time being, as he had said, upon the experience, instead of being, as he hoped it would be, upon the application to the manufacture of well-known principles, as they applied scientific principles in other cases. (Hear, hear.) But hitherto there was no doubt that the question of hardening and tempering steel had been truly a mystery, and he thought that no one more readily than the lecturer, who had interested and instructed them so much, would agree that it was still a mystery, and that those men who devoted themselves to solving those mysteries deserved well of their fellow countrymen and of the world at large. (Cheers.) There was one use of steel of which they were told, where he expected it would be extremely difficult even for the most profound chemist to tell them how to temper it. Eighteen tons of steel used daily for pens! What chemist could tell them how to temper them? (Laughter.) But he thought as regarded the steel to be used in the more innocent purpose of making weapons of destruction—(laughter)—the researches which had been made, and which would yet be made, were and would be of the greatest importance. (Cheers.)

Captain **NOBLE** seconded the vote of thanks. He said the lecturer had called their attention to the very great importance of steel. To few places, perhaps, was it of greater importance than to Newcastle, where so much of the prosperity of Tyneside was connected with industries dependent upon its use. Professor Roberts-Austen had said that a revolution had taken place during the last 26 years since the British Association was last in Newcastle. He could entirely confirm that statement. In the works with which he was connected, making a guess, he supposed that 26 years ago, of the iron they used not more than ten per cent was used in the form of steel, and about ninety per cent. in the form of iron. He did not suppose he was very far wrong now in making a guess that those proportions were about reversed. (Hear, hear.) But if they were to keep pre-eminence as ironworkers, which Mr. Ruskin was good enough to allow them, it could only be done by following researchers in the spirit which Professor Roberts-Austen had shown to them that night, and in the spirit in which that association, which was honouring them by being present, had done so much to encourage and to foster.

The vote of thanks having been passed, the proceedings ended.

THE LECTURERS OF THE ASSOCIATION.

The Association assembles as a whole body to hear the address of the President, and the discourses delivered by the two lecturers appointed by the council. The third lecture, though under the auspices of the Association, is intended exclusively for working men. Most of the best-known men in British science have been entrusted with the office of lecturer, and among the more remarkable lectures may be mentioned those of Professors Lyell, Grove, Faraday, and Sir W. Thompson.

It will be long before the Association will forget the eloquent lecture of Dr. Tyndall on the "Scientific Use of the Imagination," or the subtle refinements of that by Professor W. K. Clifford on the "Aims and Instruments of Scientific Thought" in 1872.

Professor Huxley while at Belfast in 1874 gave one of his charming discourses, the subject of which was the hypothesis that animals are automata. Among the engineering lectures that of Sir Fredk. Bramwell on "Railway Safety Appliances," may be specially mentioned, together with the one given at Bath last year by the electrical engineer Professor W. Ayrton.

The choice of lecturers is no doubt made in some cases with special reference to the locality in which the meeting is held, but since Dr. Percy lectured at Swansea in 1848, no metallurgical subject has been chosen, notwithstanding the great importance to this country of scientific advance in connexion with its vast industrial interests. In 1886, however, Professor Roberts-Austen, F.R.S., gave a very successful lecture to the operative classes on the "Colours of Metals and Alloys."

Professor W. Chandler Roberts-Austen, F.R.S., F.C.S., is chemist to the Royal Mint and Professor of Metallurgy in the Royal School of Mines. He is better known as "Chandler Roberts" than by his present name, which by Royal license he assumed in 1885, at the request of his uncle, the late Major Austen, J.P. He was educated as a mining engineer, but the late Professor Graham, when Master of the Mint, secured his services in 1865, and he has remained at the Mint ever since.

Mr. Roberts-Austen conducted the remarkable series of researches on the absorption of gases by metals, which marked the end of Professor Graham's life, and when, through the death of the latter, the office of Master of the Mint was resumed by the Chancellor of the Exchequer, Mr. Roberts-Austen was appointed Chemist of the Mint, in order that the department might not be wanting in the kind of knowledge which was possessed by the former scientific masters of the mint, Sir John Herschell and Professor Graham. He was also entrusted in 1871 with the ancient office of Queen's Assay Master, the duties of which were at that time discharged by two distinguished men, the late Professor W. A. Miller, F.R.S., and Dr. John Stenhouse, F.R.S.

Since Mr. Roberts-Austen's appointment he has been responsible for the purity of no less than fifty-five millions sterling of gold coin (£55,000,000) and thirteen millions of silver (£13,000,000), a far larger amount than any of his predecessors have had to deal with individually. No one who has not worked in the laboratory of a mint can realise how grave are the anxieties and responsibilities of the assayer, or how much vigilance is required to maintain the composition of the coin in its present state of minute accuracy.

In 1870 he was directed, in conjunction with the Hon. C. W. Fremantle, C.B., Deputy Master, to visit and report on the principal mints of Europe, and in 1884 they visited together the mints and assay offices of the United States of America. He was elected to the Fellowship of the Royal Society in 1875, and helped to found the Physical Society of London, of which he was one of the first secretaries, and subsequently became vice-president.

PROFESSOR W. CHANDLER ROBERTS-AUSTEN, F.R.S., F.C.S.

EVENING LECTURER.

(From a photograph by H. J. Whitelock, Birmingham.)

On the resignation of the late Dr. Percy, F.R.S., who had filled with great distinction the chair of metallurgy at the Royal School of Mines since its foundation in 1851, Mr. Roberts-Austen was, at the request of the Lord President of the Council on Education, permitted to accept the Professorship of Metallurgy.

Although the routine duties of his appointments have left him but little time for original work, he has nevertheless assiduously studied the influence of small quantities of matter on masses of metal. In this connexion he communicated to the Royal Society an important paper "On certain mechanical properties of metals considered in connexion with the Periodic Law," which has been published in the Philosophical Transactions. He has an accurate knowledge of the labours of the mediæval metallurgists, and the main object of his work has been to rescue metals and alloys from the oblivion to which until within the last few years they were consigned by chemists, for whom the attractions of organic chemistry had formerly proved irresistible.

There are signs that organic chemists are now turning to metallurgists for light on the molecular constitution of bodies.

Mr. Benjamin Baker, M.I.C.E., who will deliver the lecture to the operative classes, was trained as a mechanical engineer, but immediately after completing his articles he passed to the other branch of the profession, and became associated with Sir John Fowler, K.C.M.G., his present partner. He thus gained experience in work of an important and varied character, beginning with the well-known "Underground Railway" of the metropolis, and culminating in the Forth Bridge, which will be the subject of his lecture.

BENJAMIN BAKER, M. INST. C.E.
EVENING LECTURER.
(From a photograph by A. Bassano, 25, Old Bond Street, W.)

Mr. Baker is a member of the Council of the Institute of Civil Engineers, an hon. member of the American Society of Mechanical Engineers, a lieut.-colonel in the Volunteer Engineer Staff Corps, a civil member of the Ordnance Committee, and a past president of Section G.

Mr. Walter Gardiner, M.A., F.L.S., Fellow of Clare College, Cambridge, University Lecturer of Botany, whose discourse on Monday evening, September 16th, will be "How Plants maintain themselves in the Struggle for Existence," was born September 1st, 1859, and educated at Bedford, where he became captain and head of the school; and obtained the Lord Lieutenant's silver medals for natural science, chemistry, and botany. In 1878 he obtained the open Natural Science Scholarship at Clare College, Cambridge, and in 1879 was elected to a foundation scholarship.

He took first-class honours in the Natural Science Tripos of 1881, and during the following year spent some time in Germany, working under Professor Sachs, the well-known plant physiologist. In 1883 he was appointed to give a course of lectures on Systematic Botany at Girton College, in the following year was made University Demonstrator of Botany, and in 1885 was elected a Fellow of Clare College. He was one of the Rolleston prizemen in 1888, and also gained the prize given by Oxford and open to both Universities for the best original memoirs. In this year he also gave a course of lectures at the Royal Institution, and was one of the secretaries of Section D at the Bath meeting. He is the author of numerous papers published in the proceedings of the Royal, Linnæan, and other societies, and that on the "Continuity of the Protoplasm through the walls of vegetable cells" received special mention from Professor Huxley, President of the Royal Society, in his address for 1883; and Dr. J. Evans in the following year spoke highly of the one on the "Changes in the grand cells of Dionœa during secretion."

WALTER GARDINER, M.A.
EVENING LECTURER.
(From a photograph by W. M. Harrison, Falmouth.)

THE FOURTH DAY'S PROCEEDINGS.

SATURDAY, SEPTEMBER 14, 1889.

MEETINGS OF THE SECTIONS.

SECTION A.—MATHEMATICAL AND PHYSICAL SCIENCE.

The report of the Committee on Bessel's Functions was presented by Prof. A. LODGE.

In the absence of Dr. Meissel, a paper by him on "Some formulæ connected with Bessel's Functions," was communicated by Prof. HICKS.

Prof. J. D. EVERETT, F.R.S., spoke "On the Relation between Brachistochrones and Ray-paths." The author pointed out an application of well-known laws of optics to the comparison of the law of force for a free path with the law of force for a path of least time, the path itself being supposed given; and to the closely allied problem of deducing the form of the path of least time from the form of the free path when the law of force is given. Most of his results had previously been obtained by means of the principle of least action, but the optical method would be available for many students who had not mastered that principle.

Professor CAYLEY, F.R.S. delivered an address "On Curves in Space," the Right Hon. Lord Rayleigh presiding.

A paper "On the Extension and Bending of Cylindrical Shells," by Mr. A. B. Basset, F.R.S., was read by Professor A. LODGE.

Mr. T. WOODCOCK delivered an address on "Simplified Proofs (after Euler) of the Binomial Theorem."

Lord RAYLEIGH, Sec. R.S., spoke "On the Extensibility of Liquid Films."

Prof. J. A. EWING, F.R.S., discoursed on "Hysteresis in the Relation of Strain and Stress." The paper described experiments in the elastic-stretching of long wires by hanging weights, in which very delicate measurements of the extension in relation to the weight were made. By means of an optical process of magnification, an extension amounting to only one ten-millionth of the length of the wire could be observed. The object of the investigation was to test the degree of completeness with which the wire extended and retracted when load was successively applied and removed, and especially to see whether any one intermediate value of the load was associated with the same extension during loading and during unloading. The results showed an important difference between the extensions in the two cases; the difference in some cases amounted to as much as one per cent. of the whole extension. The difference was of such a kind as to imply lagging in the extension of the wire, or a tendency to persistence of previous state, which had been called hysteresis. The phenomenon was observed in wires of iron, hard steel, mild steel, brass, and copper. It did not seem to disappear in the lapse of time, and it did not disappear when the wire was subjected to vibrations. The results were probably connected with the fact well known to engineers—that materials submitted to repeated applications of load deteriorated after a time.

Sir WM. THOMSON referred to the bearing which Professor Ewing's experiments had on some performed by himself some years ago, and expressed his satisfaction with the way in which Professor Ewing had pushed the results beyond the limits reached in his own researches.

E.M.F. AND TEMPERATURE.

Professor H. STROUD, M.A., D.Sc., read a paper "On the E.M.F. produced by an Abrupt Variation of Temperature at the point of contact of two portions of the same Metal." The author stated that the results of experiments on the electric motive force produced when two portions of the same metal are in contact, and one portion is kept at a high temperature and the other at a low temperature, can be predicted from the thermo-electric diagram, and conversely a simple and direct method may thus be obtained for the determination of the Thomson effect. The precautions necessary in the performance of such experiments are discussed in the paper, and the results obtained are given in the case of copper and iron, two typical metals. The E.M.F. established in the case of copper is from hot to cold across the junction, while in the case of iron it is from cold to hot and of far greater magnitude. These experiments are being continued with a view to obtaining the relation between the electric motive force and the difference of temperature.

SECTION C.—GEOLOGY.

COAL PLANTS.

Prof. C. WILLIAMSON read a report on coal plants—the present state of the inquiry into the microscopic features of the coal of the world, and into the organisation of the fossil plants of the coal measures. He said some years ago he determined on a microscopic examination of the chief coals of the world, the object being to obtain information of the origin and formation of the coal, and especially the two dominant features of the mineral. Since York meeting coals from the following coal fields had been investigated:—Eastern Scotland, South Wales, Forest of Dean, Whitehaven, Durham, South Africa, Japan, New Zealand, India, Australia, Sweden, the Arctic regions, Nova Scotia, Borneo, South Staffordshire, and Belgium.

FOSSIL PYLLOPODA OF THE PALÆOZOIC ROCKS.

Prof. T. RUPERT JONES submitted the report of the committee on the fossil phyllopoda of the palæozoic rocks. The following were dealt with:—Aristozoe and callizoe, bactropus, tropidocaris, echinocaris, nothozoe, protocaris, ceratiocaris (patula, Ludlow; patula, Dudley; pusilla, cenomanensis, grandis), caridolites (ceratiocaris?), dithyrocaris, lingulocaris, discinocaris, estheria and estheriella (Wenjukoff's, Ludwig's, Kratow's, Weiss's, Scotch), ribieria, proricaris.

VOLCANIC PHENOMENA OF VESUVIUS.

Mr. MARR read the report prepared by Dr. Johnston-Lavis, F.G.S., secretary of the committee on the investigation of the volcanic phenomena of Vesuvius and its neighbourhood. He gave accounts of eruptions, and said it would be seen that Vesuvius had been much more interesting during the present year than last. He continued:—Much progress has been made with the two tunnels near Baja, of the new railway line. The first, or that one that enters the hill at the Baths of Nero, had been commenced before my last report, and is one that I had shown to present great difficulties in its construction. This proved to be the case, for the temperature very rapidly rose as the work progressed, so that 70° to 80° C.

was the normal temperature of the working atmosphere, which rose higher when a new face of rock was detached. In a hole made in the newly exposed rock, a maximum temperature of 93° C. was registered by one of the engineers. The workmen, absolutely naked, worked but an hour or two at a time, and came out much exhausted. I myself visited the works on various occasions, my only costume being socks and boots, and I could well appreciate the great difficulties of persistently and violently exercising oneself in this highly heated, and, above all, moist atmosphere. Fortunately, the tunnel is slightly inclined, and when work was stopped at the lower end it was proceeded with, with much greater ease, from the upper end, until at last a headway through was opened up, after which the temperature rapidly fell. Of great interest is the fact that a number of Roman cuniculi have been encountered crossing the tunnel at various angles and at different levels. Many of these are inclined passages, just large enough for a man to descend, quite similar, in fact, to those at the Baths of Nero. Where these passages reach the drainage level, they are filled by hot mineral water. The tunnelling continues on for some distance beneath the water, so that it is impossible to know how the original excavation terminates. The present state shows that we have confirmatory evidence of subsidence since Roman times. Others have a horizontal course and extend into the hills, for in some cases over 100 meters. One of these was in sufficient repair for careful observation. It enters the mountain near the road to Baja, and close to the first pozzolana quarries, after passing the Baths of Nero, and follows a perfectly straight course, till it reaches just above the top of the railway tunnel. About 50m. before its termination it divides into three, one of which descends and terminates in a very hot water, just beneath the railway tunnel. The other two branches run one above the other, the lower of which, after a short distance, turns suddenly to the right or E., and descends almost perpendicularly to join another cuniculus, which, running backwards towards the road, soon divides into two, but is choked by the falling in of the roof. This last presents thick incrustations on its walls, and on a rubble-wall support, put in at one place, at a later date, thick deposits of hyaline silica, which in some cases is crystalline, presenting apparently very minute crystals of quartz. In the first place the Baths of Nero prove to us that this point has undergone a similar oscillation of level to that of the temple of Serapis or Pozzuoli; in the next, that there has been a marked rise of temperature of this neighbourhood since those cuniculi was made. There remains, therefore, but one explanation, and that is that here the temperature has increased during the last two thousand years. I do not, however, suppose that the ground was cool, as we have historic evidence that the so-called Baths of Nero, and all the district, was renowned in Roman times for its thermo-mineral waters; and the inclined passages seem to indicate that they were used for bringing the water up, as they are nearly all in relation with the ruins of thermae. I only maintain that the temperature has augmented considerably, and seems to indicate the localisation of future eruptive action to this locality. The long horizontal passages I take to have been made to collect the vapours for the sudatorii, and the connexion I have really seen to exist in one place. If I am wrong in my conjecture as of general application, I am open to correction by competent archæologists. The second tunnel from Baja to Fusaro was made through very much cooler ground, consisting of a rather loose tuff of pozzolana with masses of large pumice. In this one a number of cuniculi were also cut through, and two of the inclined ones I was able to examine. The first, on the left, a short distance in from the Baja entrance, and on the right descended to some hot water with a temperature of 57 deg. C. Another one, some considerable distance further along on the same side, decended to hot water of 67 deg. The stone at the bottom of the little pond of water I noticed to be of an intense black colour, and on removing these they were seen to be covered by a wet sooty deposit of from 0·5m. to 1m. in thickness, and smeared over at spots with gelatinous silica, so as to have the appearance of wet stringy mucous. Although the simile is not elegant, the appearance was such that I thought, on withdrawing the first example, that some workman had spat upon the stone. A qualitative analysis proves this black deposit to be a hydrated oxyde of manganese; it must have been deposited from a water very rich in some salt of that base. During last autumn dredging operations were carried on just W. of the wooden pier at Pozzuoli, belonging to Messrs. Armstrong's works; they brought to the surface upwards of forty beautifully carved capitals and pedestals of small columns from a point which, by tradition, was the situation of the temple of the Nymphs. This fact is of value as another confirmation of the general depression of the land in this district since Roman times. The numerous trenches that are already commenced for the new sewerage system will undoubtedly afford a large amount of new and valuable evidence. In fact, the next year must be looked upon as the most important up to the present, and for many years to come, as being the one in which the most valuable geological facts will come to hand. Those new data will, no doubt, to a great extent, settle the more important questions bearing on the geology of this region, and some of vulcanology in general. Liberated as I am from the monotonous work of the mapping of Vesuvius and Monte Somma, I propose to devote myself to the study of these sections, and the results they afford; and, should circumstances be favourable, also to the investigation of some of the physics of fluid lava. I have a large amount of material on hand, but await publishing this until further excavation confirm or modify the conclusions drawn therefrom. Many of these important discoveries will be open to the party of English and foreign geologists who will visit this district immediately subsequent to the present meeting. This excursion, the first of its kind, has been organised at my instigation by that active body, the Geologists' Association, in conjunction with the Geological Societies of London and Italy, and under the hospitable patronage of the Italian Government, and especially the Minister of Public Instruction, Signor Boselli.

Professor Hull exhibited specimens of supposed coral structures from Culdaff, in Donegal.—Discussion ensued on the note.

Professor Hull exhibited a small block of magnetically polar diorite. Professor Hull was thanked for his paper.

Mr. Horace Woodward read a note by Mr. A. C. G. Cameron on the recent exposures of Kellaway's Rock at Bedford.

Mr. Watt read a paper by Mr. G. R. Vine on "Polyzoa of the Red Chalk."

SECTION F.—ECONOMIC SCIENCE AND STATISTICS.

Mr. Wm. Botly read a paper on "Agricultural Statistics." The paper gave a tabular statement of the acreage of corn, green, and grass crops; number of horses, cattle, sheep, and swine; value of corn, food, and live stock imported; of dead meat in cwts.; and value in 1887 and 1888. The author showed the number and value of the horses imported and exported were decidedly in favour of our own breed of horses in number and value. The import of wool, butter, cheese, eggs, &c., was also dealt with. The comparative yield of wheat, &c., in different countries proved the great superiority in our yield per acre. Comparative acreage of tilled and untilled land in this and other countries was also dealt with. Russia was shown to have the smallest and Denmark the largest proportion under cultivation. The United Kingdom had only 29 per cent. tilled as against 71 untilled of its acreage. The value of imported agricultural produce was shown to be £3 5s. to each inhabitant; the results of fruit-farming; and that agriculture, though the largest single interest, was only 14 per cent. of all other industries. The author considered that banking on sound principles had been a great assistance to agriculturists, especially in the trying seasons we had passed through, and which may not as yet have cleared off. He concluded by showing the utility and antiquity of agricultural statistics in the prevention of famine by quoting the 41st chapter of Genesis, &c.

Professor W. Fream, LL.D., &c., submitted a paper on "The methods of forecasting the yield of crops."

In the course of his paper the Professor said: It has become a custom in this country to make, in the early part of August, a forecast of the yield of crops—that is, an estimate as to the probable produce of the chief cultivated crops. The method adopted is to send out printed forms, or schedules, to a large number of farmers in all parts of the country, with the request that they should be returned, duly filled up, by a certain specified date. Two modes of estimation are in use. Under the one system the correspondent states whether, according to his observations in the field, each crop is "over-average," "average," or "under-average." The returns are tabulated, and a general verdict for the whole country is arrived at according to whichever of the three heads just specified secures the largest percentage of adherents. The error of this system lies in its utter vagueness, inasmuch as all over-average estimates are treated as equal amongst themselves, whilst the under-average estimates are similarly all regarded as equivalent to each other. Moreover, it is inevitable that one over-average and one under-average estimate must be regarded as equivalent to two average estimates, and, therefore, counteract each other, no graduation of over-average or of under-average estimates being attempted. The other system is free from these errors. Its essential feature involves the taking of the number 100 to represent an average crop, and increasing or diminishing this according as the crop is above or below average. Thus, 90 would indicate a crop estimated to give 10 per cent. below an average yield, and 75 would denote a crop anticipated to fall one-fourth below the usual yield. On the other hand, 150 would indicate a yield half as large again as the average. This method, being more exact, is decidedly preferable, particularly for the estimation of general numerical results applicable to the whole country. But both systems are open to serious objection, in that they take no account of area. Adopting the numerical system of estimate, it is suggested that every number indicating the current valuation of the yield of a crop should be associated with the area, expressed in acres, to which the estimate applies. Thus, an estimate of 105 and one of 95 would, at present, be considered equivalent to two estimates of 100, whereas one of the estimates might apply to hundreds of acres, and the other only to a score or so. In each case the area in acres and the numerical estimate should be regarded as factors, and the sum of all the resulting products divided by the total number of acres would give a more reliable general forecast of the probable yield per acre than has yet been obtained. In mathematical language, the general forecast should be a function both of the numerical estimates and of the area involved. The subject is of considerable commercial importance, as market quotations are influenced by these forecasts.

Discussion ensued on the two papers. In the course of the discussion an opinion was expressed to the effect that in the new departure of establishing a Board of Agriculture attention should be given to the matters indicated in the papers. Professor Fream advised those interested not to expect too much from the Minister of Agriculture.

THE HOUSING OF THE POOR.

Mr. D. G. Hoey read a paper, "Improved Dwellings for the Poor," in the course of which he said:—It is manifest that, although the greatest improvements in vital conditions were made by the cultured and intelligent, this would only serve to make still wider the already wide gulf existing between the conditions of life and the death-rate of those in comfort and those in poverty; and in order to any marked effect being produced on the general tables of mortality, the improved practice and improved conditions must be brought down to and participated in by the masses; hence the clamant importance of the question of questions in economic science—improved dwellings for the poor. The subject is a vast one, requiring great detail for its expansive treatment, but this I reserve for a future paper, and limit myself to indicating, in broad lines (1) the extent, depth, and urgency of the evils, and (2) the method proposed for their cure. Any large city will suit for illustration. Take, first, Glasgow, of which I know most. One-fourth of the inhabitants live in single apartments, nearly 70 per cent. in houses of one and two apartments, often with lodgers. The death-rate in such one and two-roomed houses is 27·74 per thousand; in three and four-roomed houses, 19·45; in houses of five rooms and upwards, 11·23. The great majority of the two-roomed houses, and a number of the single apartments, are occupied by superior skilled workmen and others of a superior class, whose mortality is much lower, and the high figure is made up by a comparatively small proportion, in which the rate is enormously high. In one district, comprising houses of all the classes, it is 42 per thousand; what must it be in the worst class there? My subject is dwellings for the poor, not for superior skilled artisans, and in most parts of Glasgow, where the poorer classes dwell, a healthy and well-trained family is not a possible thing. The rents paid for single-apartment houses are from £4 to £5, and some £5 12s. a year. Nothing but proper accommodation at similar rents, so paid for hovels, will meet the case or materially lessen the great mortality. I next take London. The best done there for the poor is as follows:—A single apartment, bare walls, 10ft. by 7ft., accommodating one person, quite unventilated, £3 18s, fifth floor; £5 12s. lower down; others, 15ft. by 12ft., same discomfort, in which a couple and some children may huddle, £7 3s. at the high and £9 2s. at the low level. These are the best examples producible of "model dwellings" of a benevolent association! Anything more wretched for model dwellings cannot be imagined. In the matter of proper house accommodation, when we come to the abodes of unskilled labourers in all large cities, the relation between supply and demand fails. The enterprise of providing improved houses for the poor is a virgin field, in which never a furrow has yet been turned. In the method of cure proposed, the chief points of difficulty are:—(1) The cost of ground, rendering it inevitable that many such houses should be erected in a limited space. (2) Providing means, within such space, for due separation and privacy of the sexes, together with (3) Thorough ventilation, producing continuous renewal of the atmosphere, whilst (4) Causing no discomfort or danger by draughts. (5) Comfortable warmth; protection from cold in winter. (6) Adequate privy accommodation, accessible to women and children. A seventh—adequate cubic space—has received great prominence, and legal enactment has prescribed a minimum of 300 cubic feet per adult; but this measure of adequacy is a dangerous delusion; the true measure of adequacy is the degree of continuous renewal of the atmosphere, and that is wholly wanting in the existing houses. The system of ventilation already described can be efficiently adopted in its essentials to such houses, adding little or nothing to the cost of erection, and I am prepared to take what cubic space can be got, facing the inevitable. The first difficulty—cost of ground—is thus removed, so far as mechanical science is concerned, whilst the third and fourth—renewal of the atmosphere without draught—have been disposed of; the fifth—comfort and protection from cold—is secured by a variety of simple devices, such as air spaces in the walls and entrances from closed and ventilated passages; and the sixth—adequate privy accommodation—is fully met in the plans. The second—due separation and privacy for the sexes, within limited space—is so important as to call here for a little detail. The plans proceed on the principle of the state cabin on board ship. Given a bare room, 15ft. by 11ft. by 13ft. high, the door 2ft. 6in. in middle of 11ft. end, leaves 4ft. 3in. on each side, enclosed by a partition 6ft. from the door, forming two bed-closets or cabins, 6ft. by 4ft. 3in. by 7ft. high. The partition is carried up to the ceiling, enclosing another bedchamber, 11ft. by 6ft. by 6ft. high. The cabins are each fitted with two berths, 6ft. by 21in., leaving floor space 6ft. by 2ft. 6in., furnished with lockers and seat and cupboard. The bedchamber above has a bed 6ft. by 4ft., and floor spaces 6ft. by 5ft. and 4ft. by 2ft., with 11ft. range of lockers and a large cupboard. The space left for the family room is 11ft. by 9ft. and 13ft. high. There are numerous other provisions for convenience and comfort, including a cheap economical stove, that burns any slack to white powder, does the cooking, the warming, and the ventilating all at once; and every other provision has been made, down to the minutest particular, for economising space and cost of erection and of working. The stove has been tested and proved capable of giving a renewal of the atmosphere every hour, twice the 300 cubic feet supposed to be sufficient for a whole night; so that, whilst, without such arrangements, the adequate space of the statute is a delusion and a snare, with them, any space, legally adequate or not, may be kept at all times, and without intermission, in atmospheric purity and comfort.

Mr. Macknight said the habits of the wretched classes referred to must be reformed in the first instance. If they put a pig in a drawing room it would not be a drawing room very long.

Dr. Barron (Southport) said so long as we kept these people in the courts and alleys of our great cities, reform in their habits could never be brought about. The first point was to improve the dwellings of the poor, and reform would follow as a consequence.

Mr. Hodgkin (London) referred to the building of working men's dwellings on the co-operative principle, and alluded to a scheme on such lines which was being successfully worked in London.

FICTITIOUS CAPITAL.

Mr. L. L. Price, M.A. (secretary) read a paper written by Mr. Hyde Clarke on "Increase in Europe and America of nominal or fictitious capital." The writer referred to the history of the joint-stock system in the United States, France, and England, under which fictitious values in shares or stocks were created for goodwill or other matters, which did not represent real or effective capital. Of late years these sums had reached very large amounts, and, being treated by statists, economists, and journalists as real amounts, led to erroneous conclusions. Thus, in England, month after month, large columns of figures were given adding up the capitals of projected companies, which, if they represented real sums, would suggest the danger of a panic time after time. No such panics occurred, because these amounts were chiefly transfers of nominal sums from one individual to another in the purchase or sale of breweries, gold and other mines, patents, mercantile businesses, &c. In many cases such companies were mere family arrangements to avoid the mercantile risks of individual liability, and where no real change of condition or constitution of effective capital occurred. These operations, carried on by promoters and adventurers, had reached such an extent that they demanded the careful consideration of economists. In a time of panic, although no real destruction of the national capital may take place, the suffering to individuals from fluctuation of price will be very great. Even where a profitable business is carried on, great depreciation of the market price of shares and debentures will take place. At the present time the rate of investment is little above three per cent.; and a brewery returning £100,000 per annum would be marketable on the scale of the rate of interest on investments advancing to five per cent., but there would be a great change and large depreciation. Still more would this be the case when, as in recent panics, six or seven per cent. was required as a return on investments.

SECTION G.—MECHANICAL SCIENCE.

ESTUARIES.

Professor Osborne Reynolds, of Manchester, presented the report on investigations of estuaries by means of models. He said the report arose out of a communication of his own to the section at Manchester. At that meeting the section was kind enough to consider the communication of sufficient importance to suggest that a committee should be appointed to continue the investigation, and through the action of members of that committee, the association was kind enough to allow a grant of £200 for the continuation of the investigation of that matter. It was a subject of great importance, relating, as it did, to the *régime* of estuaries; and it was an investigation of very considerable difficulty. In all estuary work, the circumstances were extremely difficult to deal with, on account of the extremely limited experience which could be brought to bear on any particular estuary. The time taken for any change in an estuary or harbour was so great that individual experience hardly ranged far enough. The time between surveys was often ten years, and change was going on all the time. The question was whether they could get results by means of model estuaries, and accordingly the committee commenced its investigations in the Whitworth Laboratory at Owen's College, Manchester. There were two tanks, designed for the limited space in the laboratory, the larger tank being 23 feet in length and 10 feet in width, and the other being exactly of half the dimensions. At the lower portion of the tank was a fixed tray, representing the beach, and at the head of the tank was a tide generator, or ocean—whichever they liked to call it. This latter portion of the tank was made to oscillate and produce tides. They had 13,000 gallons of water at the height of 116 feet above the laboratory, and they used a Bayley's water motor to drive the generator; and the motor had run through something like 20 million revolutions during the course of the experiments. They could only compare their results by survey, and the sand had to be taken out before any experiment. He exhibited diagrams of surveys taken last Saturday and Monday. The tide levels were taken by a tide gauge. Their first idea was to compare the results of the models of estuaries. They had settled that, from the difficulty of obtaining accurate surveys of estuaries, they would not begin by attempting an estuary, but would run model against model, and see if they could prove identically similar results in the two models. The simplest of all forms of estuary was one without any lateral boundaries—an estuary with infinite breadth, so to speak—with straight lateral sides. There were two questions: Would the sand attain a beach-like form? Would it slope up and down, as they so often saw on the shore of beaches? or would it groove and form low-water channels and banks, as they saw so often in estuaries? The other question was, would it attain any definite slope, and would they be able to get out a certain law of slope? Professor Reynolds described in detail a series of experiments made in the two tanks. In the large tank the tide came up and down every fifty seconds. There were eight feet of sand with an inch of water on it. At first a tremendous effect was produced on the sand. It took a long time to produce any real adjustment in the sand. Every day sand gauges were recorded, showing them the daily alteration in the position of the sand in longitudinal section. After running about 16,000 tides the sand seemed to them to have got into a very stable condition. They therefore stopped the model and took a chart. The bar lines showed that there were low water channels and banks. The estuary at that stage was not beach-like or perfectly level. At the previous stage it had been much more beach-like: the banks had come out at a later stage. They put into the tank waves six inches long and three-quarters of an inch deep. They kept these on for 17,000 tides, and they then made a survey. There was very little alteration in the sand; the low-water line had gone down a little. The detail of the banks, the general slope and appearance were almost identically the same. They ran the second tank under similar circumstances, and got almost identical results, as far as appearance went. The results proved that in the general slope of the sand they got an agreement between one scale and another; and this agreement was apparent in the two tanks at each corresponding stage. The experiments were not complete, and they hoped to go on to V-shaped estuaries. The results of their experiments up to the present were most satisfactory, and he had great faith in the agreement between the models and estuaries.

Professor Reynolds was cordially thanked for his report.

PETROLEUM SHIPS.

Mr. A. R. Liddell read a paper on "Ships for the

"Carriage of Petroleum." He said the petroleum ship industry began on the Tyne about five years ago, when the steamship Glückauf was built by Sir W. G. Armstrong, Mitchell, and Co. for Herr Riedemann, of Bremerhaven. Some early ships—the Vaderland, Nederland, and Switzerland—were built by Messrs. Palmer and Co., of Jarrow, in 1872, to carry petroleum in bulk, but they were never employed in the trade. Prior to 1886 some ordinary cargo vessels underwent costly alterations, and were converted into petroleum carriers, but were only partially successful. Petroleum was at first carried in wooden sailing ships, in barrels or boxes in the hold; but under these systems a much smaller amount of cargo could be carried, and the barrels and boxes were very costly. The later petroleum steamers are commonly spar-decked, and range from 250 to 300 feet in length, and from 1,500 to 2,500 tons gross register. They have their machinery aft, oil-holds up to the main deck, and a long trunk from 10 to 15 feet wide from the main to the spar deck. The latter acts as a feeder, and allows the oil to expand and contract within it without dangerously affecting the vessel's stability. To have the holds half full, with the oil free to wash about, reduces the ship's righting moment, and special care has to be taken in loading and discharging. Water ballast tanks are commonly fitted, and a peculiar saddle-shaped tank, patented by Mr. Henry F. Swan, has been found specially useful. The oil-hold is divided into compartments by a centre line bulkhead and by transverse bulkheads about 20 feet apart, and the ordinary structural details are modified in many respects on account of the greater difficulties attending oil-tight work. The surveyors of Bureau Veritas have done very much to help forward this industry, while their rivals of Lloyd's Register have remained comparatively inactive. These vessels are all supplied with powerful pumps, and have large oil and water mains led along the main deck, with branches into the holds and connections to meet pipes from the shore. The oil is pumped into large reservoirs at the port of discharge. A cargo may consist of several qualities of oil, and these are separated from each other by narrow water-spaces. The sailing ship Hainaut was built about two years since by the Barrow Shipbuilding Co. for Messrs. F. Speth and Co., of Antwerp, to carry petroleum in bulk in competition with the steamers, and proved successful; and it is suggested that the example might be advantageously followed by others. Petroleum vessels cannot be used for other purposes, on account of their peculiar arrangement and smell. A proposal to carry palm oil in a similar manner has hitherto been found impracticable on account of corrosive ingredients, which attack the steel in place of preserving it as petroleum does. Electric lighting is resorted to to lessen the danger of fire. The petroleum industry is expected to increase in the future, and it is hoped that the Persian and Arabian deposits of oil may before long be worked.

Professor JENKIN, Glasgow University, said the industry was a new one, and showed signs of great activity on the Tyne and on the Clyde, and he had no doubt that for some time to come the building of petroleum-carrying vessels would continue to become an important branch of the shipbuilding industry. In 1864, sailing vessels were constructed on this coast for the carriage of petroleum in bulk, and so long ago as the end of last century the Persians were know to carry petroleum in bulk in their own vessels in the Caspian Sea. He regretted to hear Mr. Liddel's remark about Lloyd's register, and thought it was due to a misapprehension as to the duties of a register society. A register society occupied a very important position as between shipowners, those who insured the ships and those who sent their cargoes by them, and it would never do for a register society to rush into all kinds of new speculations without having some assurance, some experiment beforehand, to show that they were really reliable and would in the end prove successful.

Mr. CHAS. HAWKSLEY, M. Inst. C.E., suggested that valves should be placed near the bottoms of the divisions of the different compartments, which, being opened during the operation of loading and discharging, would permit the oil to flow equally into all compartments, and so get over the difficulty of keeping the vessel in proper trim, and not subject it to undue strains.

Professor JENKINS said this would inevitably lead to the loss of the vessel by capsizing.

Mr. LIDDELL, in answer to a question, said the oil gave off a vapour that was very inflammable, and it was necessary to use safety lamps.

ANTI-FOULING COMPOSITIONS.

Mr. M. HOLZAPFEL, Newcastle, read a paper on this subject. He said:—The invention of a means for protecting the bottoms or immersed parts of ships against fouling, and the worm in the case of wooden ships, and subsequently against fouling and rust in the case of iron ships, has long occupied human ingenuity. The Phœnicians over 2,000 years already employed a composition consisting chiefly of asphaltum for this purpose, and relics of the ancient Romans prove that they employed lead and copper sheathing on the immersed parts of their ships. Before iron shipbuilding was introduced, as early as the middle of the 16th century an anti-fouling composition was patented in this country, but after the invention of yellow metal, compositions in the form of paint were seldom used till iron shipbuilding necessitated the use of a paint or composition to protect the iron against rust and fouling. Hardly a month now passes in which one or more patents are not applied for under the name of "anti-fouling compositions." This is a proof that the desire to invent a means for preventing the fouling of iron and steel ships occupies many minds. It is therefore surprising that there should be an almost total absence of literature on this subject, and that a perusal of mostly all the specifications which are filed from month to month should prove that even many of those who may be supposed to have given a great deal of time to the study of this subject should, to judge from their specifications, appear to be quite unaware even of the most elementary principles on which alone a successful anti-fouling composition can be based. In 1867, this subject was dealt with at considerable length by Mr. Charles F. T. Young, C.E., who gives the results of a number of important experiments by the British and French Admiralties and others, but who deduces from them the most conflicting and illogical theories. At this year's meeting of the Institution of Naval Architects, Professor Lewes read a short paper, the outcome of a very exhaustive and painstaking research, but even he seems hardly to grasp the subject and misinterpret some of the phenomena. With our daily extending fleet of iron and steel ships, this question continues to grow in importance, and I will therefore endeavour to lay down the broad principles on which a successful anti-fouling composition should be manufactured. The way to obtain this object is to imitate as nearly as possible the action of copper and yellow metal. When iron ships were first introduced, great difficulty was experienced to apply any substance which would even in a measure preserve the iron and prevent fouling for a reasonable period. Dry dock accommodation at foreign ports then was exceedingly limited, and a vessel could only de dry docked after the return from her voyage. A man-of-war on commission in foreign or colonial waters, for an extended period would, before she came home and before she could get cleaned, become so foul as to be almost unmanageable and unseaworthy. What the Government and private shipowners hoped to attain at that time was a composition or material which could be applied to iron or steel ships, and which would last for two, three, or four years without being renewed. Many of the various patent compositions, whose manufacturers professed that they would achieve such a result, proved themselves entirely inadequate, and barely lasted six or eight months. Others, besides fouling very rapidly, also corroded the iron to an alarming extent. In consequence of this, scientific and practical men endeavoured to introduce a method by which copper, yellow metal, or zinc sheathing could be applied to iron ships. Such methods did exist, and are occasionally, even now, resorted to, but they could only be carried out at very great expense and at comparative loss in speed. The method adopted is to cover the iron under water part of the ship with wood sheathing, one to three inches thick, and to nail the copper or yellow metal over this. There is, however, this drawback—that water is very liable to penetrate between the wood and iron skin of the vessel, and thus to cause corrosion, which remains undetected till the wood covering is removed. Moreover, the wood covering has to be fastened to the ship by iron or copper bolts, which in either case serve as a contact between the iron hull of the vessel and the copper sheathing, thereby setting up galvanic action, which is highly destructive to the iron hull of the ship. Mr. Young, in the work above referred to, recommends, as the outcome of his experience and studies, to fasten zinc sheathing to the ship without an intermediate sheathing of wood. The fact that this method is out of use at present, although it was exhaustively tried, completely disposes of it. The building of dry docks in all important harbours of the world, and the rapidity with which vessels are now cleaned and painted, have made it unnecessary to have a composition which will stand as long as yellow metal. In any ease, it has been found desirable to dock ships at least once in twelve months to sight bottom, and, therefore, a composition which will keep a ship's bottom clean for twelve months in ordinary trades is at present likely to meet with the best success. It must, moreover, comply with the following conditions:—Firstly, it must absolutely protect the ship against rust; secondly, it must have a very smooth surface, so as to reduce surface friction to a minimum; thirdly, it must be quick-drying, so that, if necessary, a steamer may receive two coats in one day. Even if in a composition, drying more slowly, better antifouling properties could be introduced, it is very doubtful whether such a composition would prove a commercial success, because the frequent chafing of our huge iron ships against piers, small craft, and anchor, chains, &c., removes considerable quantities of composition from the ship's bottom, and thus exposes the iron to the action of the salt water, and it has been found absolutely necessary to recoat once in twelve months for this reason alone, It is not difficult to make a composition which will in ordinary trades preserve the vessel against rust where she is not chafed, and against fouling for such a period, unless she is exposed to exceptional delay in waters which are very productive of fouling matter. Now, as to the antifouling properties, there are two methods by which they are supposed to be obtained: Firstly, exfoliation, *i.e.*, the separating of small particles of the composition from the main body, by which any animal or vegetable growth which may have attached itself, is caused to drop off the bottom of the vessel, and secondly, the poisoning, by which the fouling matter is supposed to be killed either before attaching itself or after. Some scientific and practical men attribute the antifouling properties of copper, yellow metal, and zinc sheathing solely to exfoliation, others to the poisoning principle only. Mr. Young belongs to the former category, and Professor Lewes, without distinctly saying so in his paper, strongly leans in that direction. Both and all are, in my opinion, wrong, for it is only from the fact that copper and yellow metal only poison when they exfoliate that they become antifouling, and it is only metals and compositions which in exfoliating produce poisons that are effective antifoulers. Mr. Young, as well as Professor Lewes, give instances in their papers of cases where the galvanic action of the salt water on the copper has been neutralised by iron and zinc protecting bars, and where, consequently, a great deal of fouling was found on the copper. They both say that when the copper ceased to exfoliate it ceased to be antifouling, and they try to deduce from this that is is only the exfoliation which is wanted, not the poisoning. My argument is this, that when the copper exfoliates, it produces a poison (oxychloride of copper), which is highly destructive to the lower animal and vegetable life, and that this poison is the active antifouler which kills the fouling matter before it can attach itself. Now, if the exfoliation of copper alone prevents fouling, why does not the exfoliation of metallic iron also prevent fouling? I may say that it does so to a very limited extent, but not because it exfoliates, but because by coming into contact with salt water the surface of the iron plate is transformed into rust, which also is to some extent poisonous, but not sufficiently to prevent fouling in any but the coldest climates. Now I think everybody present will bear me out that an iron plate when exposed to the action of salt water for four years will lose at least five times as much of its weight, *i.e.*, will suffer five times as much exfoliation as a copper or yellow metal plate. If, therefore, exfoliation were the real and true factor which prevents fouling, iron itself should be a much more effective antifouler than copper. Some people may argue that the success often obtained from the use of zinc white and tallow, which cannot be considered in themselves highly poisonous substances, is a proof that after all exfoliation if not the only, is still an important factor as an antifouler. But zinc white and tallow when in contact with salt water become highly poisonous, and their chief merit lies in the poisoning principle. If a mixture of pure vasiline, mixed with chalk, were applied, the exfoliation would be equally good, but I need hardly say that the coating would quickly be covered with fouling matter to such a thickness as to stop the progress of exfoliation altogether. Exfoliation can only act as an antifouler in regard to substances which adhere lightly to a ship's bottom, not in regard to shell which seem to eat into the protective coating till they finally find a firm hold on the bare iron. I may, therefore, say that exfoliation is not an active factor which prevents the adhesion of animal and vegetable life, but a passive agent, which may under circumstances cause the formations which have already adhered, to again detach themselves from the ship. For in dealing with the first developments of animal and vegetable life, which constitute fouling, we have not a body heavier than water, which if it does not find a sufficiently hard hold to keep on the ship, would fall off by itself, but we have a hungry and most insidious animal or plant, which will live on anything that is not an active poison. The poisoning principle is therefore this, that the anti-fouling substance must surround the ship with a thin layer of poisoned water, which destroys all animal life that enters it; and you cannot poison an animal unless it absorbs some poison. So this poisoned zone gets gradually absorbed, and must be replaced. This replacement is effected in copper sheathing, as well as in antifouling compositions, by a gradual dissolution of the main substance which, in being dissolved, becomes highly poisonous. Mercury, copper, arsenic, and zinc, in certain forms, are the substances mostly used for compositions, and they must be used in a varnish which will dissolve with sufficient rapidity to admit of these substances continually combining with salt water, and at the same time with sufficient slowness to retain part of them for the length of time for which the vessel will be exposed to the influence of fouling. We may now take it as granted that a successful antifouling paint must contain a considerable amount of poison which will destroy animal and vegetable life in its lowest developments; and that this paint must slowly dissolve, or corrode, or if you like, exfoliate. Whether these poisons are poisons in the ordinary acceptation of the word, or not, does not matter, they must merely be poisons to the class of animals and vegetables which try to attach themselves to a ship's bottom, and they must carry the greatest possible efficacy in the smallest possible volume, and, as already stated, these animals and vegetables must be poisoned in their first stages of development, in which only they try to attach themselves to a ship or other solid substance, for when they have once attached themselves they grow rapidly, and can stand a great amount of various sorts of poisons, which is evidenced by the fact that a mussel can thrive on a quantity of verdigris which would poison a healthy man, also by the fact that large sized shells several inches long are not infrequently seen on copper sheathing where they could not fail to absorb a large amount of poison from surrounding parts of copper. It will be seen, therefore, that even copper is not a perfect antifouler when exposed to trying circumstances, when, for instance, animal and vegetable life in the surrounding water is so strong that all the small particles of poison get absorbed, and before new formations of poison can take place, the animals attach themselves to the ship.

Now, when they have once attached themselves the poisoning factor generally becomes useless, the animals grow, and the ship comes home foul, often to the astonishment of the owner, captain, and composition manufacturer, and this not only occasionally takes place with the best compositions, but also with copper and yellow metal. I referred above to preparations of mercury, copper, arsenic, and zinc. All of these are supposed to cause corrosion of the iron particularly copper, which consequently should not be used at all, or only to a very limited extent. But in each case the antifouling coating should be separated from the iron by a coating of anticorrosive paint. Many years ago red lead was taken for this purpose, but it has now been almost completely displaced by quicker drying and more protective varnish paints, which should be so constituted that even if they are exposed to the action of the salt water their dissolution would be so slow and gradual as to be almost imperceptible. Many vessels of the mercantile marine have such a solid and hard body of these protectives on their bottom that absolutely no rust can be seen on them except on places where the paint is chafed off. As to the antifouling, or second coating, I have already stated that the varnish conveying the antifouling ingredients should be so constituted as to allow of a gradual but very slow dissolution in salt water, so as to set the antifouling or poisonous matter free. Now in varying waters varnishes of various hardness may be used, in the tropics a soft and rather quickly dissolving varnish, in Northern waters a hard and slowly dissolving varnish. In an experience of over ten years, I have absolutely satisfied myself that most mercurial varnish paints on competitive trials will invariably show a better result than any other compound, while the preservation of the iron and the smoothness of the surface are unequalled. These paints, moreover, are so cheap, and dry so rapidly, that the total expenditure of a steamer for docking, cleaning and painting during four years is considerably less than a single outlay for docking and sheathing with yellow metal, which under favourable circumstances will only last the same period, *i.e.*, four years. It seems to me very doubtful, whether a composition lasting longer than twelve months, provided it were dearer than those now in use, would meet with favour, because most shipowners are already under an obligation to their underwriters or the Board of Trade to dock their vessels at least once in twelve months (which, moreover, is desirable in order that the seacocks, propeller, rudder, &c., may be inspected) and the cost of antifouling paint, if intelligently bought, is a very small one indeed. The tendency, on the contrary, seems to be, to economize further in the cost of the paint, and to dock the ships more frequently, for the prices for dock dues and labour for painting, and the time required for this purpose, are in most parts only one-third or one-fourth of what they were 15 years ago, while the additional speed of a newly cleaned and painted bottom is a great desideratum. The only improvement therefore which may be looked forward to, might be the substitution of mercury by some cheaper substance, which would be at least as destructive to fouling matter as mercury. I forsee no chance of a compound being invented which would be hard enough to withstand chafing and which could at the same time be used to convey sufficient antifouling materials in a suitable and effective manner. All we can therefore expect from the immediate future is comparative perfection within the radius in which we now move, *i.e.*, a perfect adjustment of the various gums used in preparing the varnishes and of the various antifouling materials now known, so that the composition may be quite reliable even in cases where the various paints now used sometimes fail to fully answer their purpose.

MANUFACTURE OF ALUMINIUM ON THE TYNE.

The members of the committee of Section B (Chemical Science) went to Wallsend, and paid an interesting visit to the works of the Alliance Aluminium Company. They were met by Dr. Netto, the inventor of the various processes, who obligingly conducted them over the works, explaining the processes and answering the numerous questions asked by the visitors. The comprehension of the manufacture was much facilitated by the excellent description of the process which had been given in the section by Dr. Bedson at the sitting on Friday. In the first portion of the works visited, the manufacture of sodium was being carried on. The process is dependent on the decomposition of caustic soda by heated carbon. Cast iron retorts are filled with carbon, and heated to a dull red heat. Fused caustic soda is then allowed to flow on to the heated charcoal. The carbon unites with the oxygen of the sodic hydrate, while sodium and hydrogen are liberated. This change is accompanied by another, in which the products are carbonic oxide, sodium carbonate, hydrogen, and sodium. The volatile products pass from the neck of the retort into a flattend iron tube which is cooled by the surrounding air. In this tube the sodium condenses into the liquid state, and flows out from the end of the iron tube into a receptacle placed below to receive it, and many of the chemists present were not a little surprised to see liquid sodium passing through the air with comparatively little loss. The inflammable carbonic oxide and hydrogen burnt at the end of the iron tube with a flame strongly coloured with the well-known sodium yellow, which gave a very ghastly appearance to the visitors present. From time to time a tubulure at the bottom of the retort is opened and the sodium carbonate mixed with undecomposed hydrate is drawn off.

The sodium thus manufactured is employed for the reduction of aluminium from cryolite, a mineral consisting of a double fluoride of sodium and aluminium. This mineral is mixed with common salt, and the mixture fused in a reverberatory furnace. When the mixture is quite fluid the furnace is tapped, and the liquid mixture is run out into an iron pot, called the converter, and a piece of sodium, about 5lbs. in weight, is thrown on to the liquid, and immediately pushed below the surface by means of an inverted ladle attached to a rod with a cross handle, which is held by two workmen well protected with thick gloves and masks. The ladle is raised and lowered, and the sodium well mixed with the melted cryolite. Much heat is evolved by this reaction, but it is much less violent than might be expected. The sodium combines with the fluorine of the fluoride of aluminium contained in the cryolite, producing fluoride of sodium and metallic aluminium, but this aluminium is not pure being contaminated with iron and silicon from impurities present in the native cryolite. The fused mass is next poured off from the metal (which contains about 90 per cent. of aluminium) into another iron pot, where it is treated with a further amount of sodium in precisely the same manner as before. As the impurities have been to a very large extent removed by the first treatment with sodium, the metal obtained in this second process is much purer, containing from 95 to 98 per cent. of aluminium. The contents of the iron vessel are then poured out into an iron mould and allowed to solidify, when a button of aluminium is found at the bottom, covered by a slag consisting of sodic chloride, sodic fluoride, and some undecomposed cryolite. These slags have a grey colour due to the presence of finely divided aluminium, which separates imperfectly from the slag owing to its low density. In order to recover this aluminium the slag is fused with copper in a reverberatory furnace. The copper unites with the aluminium, forming aluminium bronze, which is now much used in the arts. Another process for the manufacture of a still purer variety of the metals was shown, in which a purer cryolite was used and fused in a crucible with common salt. While the crucible is still in the furnace a lump of sodium is taken up by means of a pointed rod, thrust into the melted mass and stirred up with it by means of an iron dish on a handle. The slag is then poured off and the metal run into an iron mould. The visitors were next shown the casting of sodium. The metal is melted in iron pots, ladled out, and poured into cylindrical moulds of different diameters. When the metal has solidified the moulds are opened and the metal weighed, cut into proper lengths, placed into tin boxes which the cylinders nearly fit, and the lids of which are soldered on. The store room at present contains about eight tons of sodium, which metal was not so very long ago sold at the price of 24s. per ounce. A visit was next paid to the aluminium store, in which the metal in various forms is kept. There bars and cakes of aluminium of different sizes were seen, and also bells made of the metal. The peculiarly sonorous character of aluminium was shown by striking bars suspended by strings. Some specimens of cryolite were also seen, some of them containing beautiful crystals of spathic iron ore, interesting to the mineralogist, but very obnoxious to the manufacture of aluminium. Finally the visitors were delighted by presents of specimens of aluminium foil as brilliant as polished silver, and a charming expedition was brought to a close.

THE EXCURSIONS.

VISIT TO DURHAM.

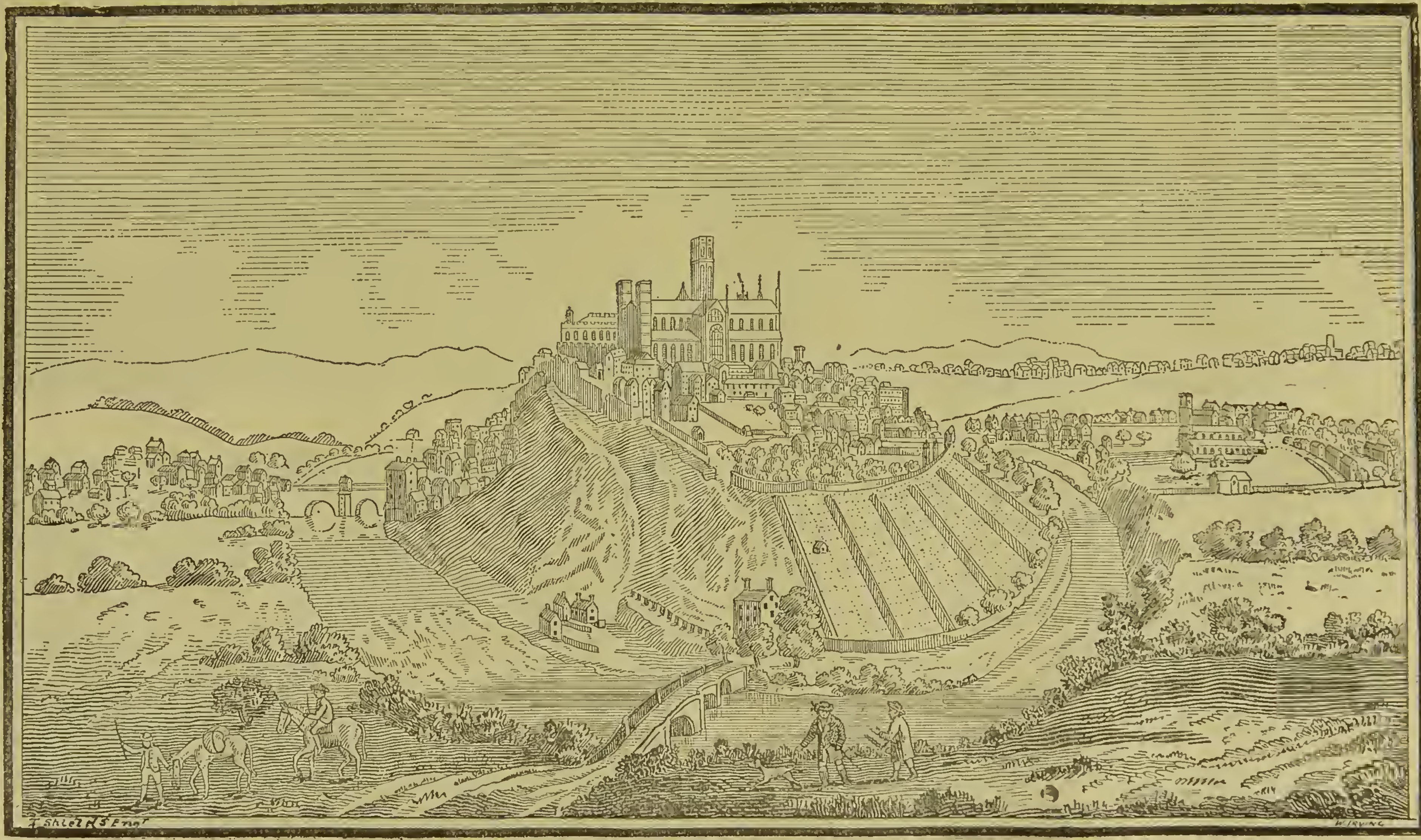
CONFERRING OF DEGREES.

The largest of the excursions on Saturday was that made by the principal members of the British Association to Durham, where they were entertained by the University to luncheon, and where afterwards the degree of D.C.L., the most important which the University has the power of giving, was conferred upon eleven of the most famous of the members. Nearly four hundred ladies and gentlemen took part in the excursion, travelling to Durham by special train, which left the Central Station at a quarter-past one o'clock, and arrived in the ancient cathedral city half an hour later. Immediately on their arrival, the invited guests made their way to the University College, where luncheon was provided in the old dining hall. The Warden, Dean Lake, being away from home, the chair was taken by the Sub-Warden, Professor Pierce. At his right sat the President of the Association, Professor Flower, and at his left the ex-President, Sir Frederick J. Bramwell. There were also present :—Sir Frederick Abol, Canon Tristram, Sir B. C. Browne, Sir C. M. Palmer, M.P., Mr. Wm. Anderson, M.I.C.E., Mr. Glaisher, F.R.S., Prof. Green, Oxford ; Prof. Hull, Director of the Geological Survey of Scotland ; Prof. Geikie, F.R.S., Director-General of the General Survey ; Mr. Roberts-Austen, Royal Mint ; Mr. Chas. Hawksley, C.E., F.R.S., Dr. Slater, Rev. Dr. Crossky, Mr. Bloxham, Mr. De Rance, H.M. Geological Survey ; Dr. Blandford, President of the Royal Geological Society; Prof. Osborne Reynolds, Manchester ; the ex-Mayor of Newcastle (Mr. W. D. Stephens), the Sheriff of Newcastle (Mr. W. Sutton), the Mayor of Gateshead (Ald. J. Lucas), Ald. T. G. Gibson, the Rev. J. C. Bruce, LL.D., Mr. Gainsford Bruce, Q.C., M.P., Dr. Arnison, Dr. Drummond, Dr. Murphy, Dr. Hume, Principal Garnett, Dr. Embleton, the Rev. Canon Lloyd, Vicar of Newcastle ; Sir Douglas Galton, Mr. A. G. Vernon Harcourt, Col. Sir F. de Winton, Prof. F. Y. Edgeworth, Prof. Sir W. Turner, Prof. W. Andrews, Capt. W. de W. Abney, Dr. Woodward, British Museum ; Mr. R. R. Redmayne, Mr. J. S. Swan, the Right Rev. Bishop Sandford, the Rev. A. Shortt, the Rev. J. Haworth, Principal of the Female Training College, Durham ; the Rev. J. Bulmer, Shincliffe ; Mr. J. Shields, J.P., Durham ; Mr. J. Grieves, M.A., Durham ; the Rev. T. Randell, Principal of the Male Training College ; Mr. E. Gleadowe Marshall, Durham ; Professor Jenkins, Glasgow ; and many others. The guests were received in the hall by Dr. Pierce, and in the dining room by Dr. Philipson, of Newcastle.

After the health of the Queen had been drunk,

The CHAIRMAN proposed the health of the President, the late President, and the other distinguished officers of the British Association. He said that, in the absence of the Warden of the University, it was his pleasant duty to welcome the association to that ancient city, and to express their sense of the honour they had conferred upon them in permitting them to invite so many of their distinguished body. They were a small university — small in numbers and in endowment, and they were young ; and the early years of their existence had been years of prolonged struggle. But the fact that they were alive to-day, and that they had honoured them with that visit, would, he hoped, suggest that they were taking advantage of that widespread law, the survival of the fittest. (Laughter and applause.) They had practical illustrations of the activity in the new buildings of the Colleges of Medicine and Science at Newcastle, which had been so auspiciously inaugurated by being used for the purposes of their society. (Applause.) A greater honour could not have been conferred upon them than had been conferrrd upon them by their visit that day. That old baronial hall had witnessed many gatherings, going back, as it did, to the times when the British Association was represented by a single member, he supposed—Roger Bacon. (Laughter.) But he doubted if it ever welcomed so distinguished a gathering as that which was assembled there that day. The work they had done and were doing was before the world, and any mere expression of opinion would be irrelevant. As a university, they might be permitted to convey to them their earnest wishes for their continued success, and to thank them for that opportunity of expressing their deep and earnest respect towards the British Association. (Applause.)

Professor FLOWER said that, on behalf of the British Association for the Advancement of Science, he begged to thank Dr. Pierce and the authorities of the University for their hospitable entertainment they had given them that day, for the opportunity of visiting that interesting place, and also for their recognition of the objects and work of the association, [by conferring, as they were about to do, the honorary degrees of their University upon some of their representatives. They previously had an opportunity of admiring at Newcastle what the University of Durham was doing in the way of the advancement of modern science. The applause with which the mention of the new buildings at Newcastle was received showed that they all joined in giving the testimony of their appreciation of the admirable way in which the colleges had been arranged, so far as they were completed, for a great deal yet remained to be done. He had seen many medical schools in the kingdom, but he never saw one that was, for its size, so luxuriously furnished and ordered as the College of Medicine in Newcastle. (Applause.) With the picturesqueness of its situation and the magnificence of its buildings, Durham was quite unique in the places of this country. The University was



VIEW OF THE CITY OF DURHAM IN 1779.

associated with everything that was old and venerable and beautiful in the city of Durham. It seemed to him that there they had epitomised all the elements that made the life of a man complete and beautiful. They had the modern scientific advancements, and they had the venerable traditions; and those of them who were to be so fortunate as to be honoured by receiving its degree that day would always associate that degree with everything that was beautiful and good, in their noble cathedral, in their splendid castle, as well as in what was being done for the advancement of science in the college and elsewhere. In the name of the association, therefore, he offered most hearty thanks for the recognition of the association by the Universiity of Durham. (Applause.)

The Rev. Canon Tristram said he was requested by the Dean and Chapter to say that they trusted the President and members of the association would honour them by their presence at the old bowling green of the monks after the afternoon service in the cathedral.

This concluded the proceedings at the luncheon.

A special meeting of Convocation was then held in Bishop Cosen's Library, for the purpose of conferring the honorary degree of Doctor in Civil Law upon the following members of the association :—

Sir F. J. Bramwell, D.C.L., F.R.S., M.I.C.E.
Professor W. H. Flower, C.B., LL.D., F.R.S., &c.
Captain Sir D. Galton, K.C.B., D.C.L., F.R.S., &c.
A. G. Vernon Harcourt, M.A., LL.D., F.R.S., &c.
Captain W. de W. Abney, R.E., C.B., F.R.S.L., &c.
Professor J. Geikie, LL.D., F.R.S.L., F.G.S., &c.
Colonel Sir F. de Winton, K.C.M.G., F.R.G.S., &c.
Professor F. G. Edgeworth, M.A., L.S.S.
W. Andrews, Esq., M.I.C.E.
Professor W. Turner, M.B., LL.B., F.R.S.L., &c.

IN ABSENCE.

Professor A. W. Williamson, Ph. D., LL.D., F.R.S., &c.
Professor J. S. Burdon-Sanderson, M.A., M.D., LL.D., &c.

The Sub-Warden presided, and the other members of the Senate with him were Professor F. B. Jevons and the Rev. J. R. Short. There was a very large attendance, the long room being filled to its utmost capacity. The Sub-Warden and his two supporters sat in ancient-looking beautifully carved chairs at the head of the room, and in front of them, for some distance down each side of the room, were the professors, doctors, &c., in their gowns and their hoods of scarlet, purple, and other striking and attractive colours. The spectators were crammed tightly down the whole length of the library, and those at the further end of it must have obtained no more than a very scanty view of the ceremony that was conducted in the space round which so many men of light and learning were congregated. When the Sub-Warden and proctors and the others had taken their seats, an usher with a wand marched up the centre of the room, directing the progression of the prospective recipients of the degrees, who were accompanied also by Dr. Philipson, Canon Tristram, and Principal Garnett, who were to present them. The learned men stood in a group before the presiding trio, and it must in truth be admitted that, dignified as they might have been expected to be, they began to appear somewhat uncomfortable and unhappy long before the proceedings terminated ; and, as one after another of the recipients was "capped" and had left his fellows, those that remained looked more than ever as if they heartily disliked the whole business.

The Sub-Warden, in opening the proceedings, said : The purpose of this Convocation is to confer honorary degrees on the distinguished officers of the British Association. The Registrar has something to read.

The Registrar, however, intimated, in an audible whisper to the sub-warden, that he had nothing to read.

Dr. Philipson then singled the President of the Association from among the others, and held out his hand. Prof. Flower did not appear to have been tutored in the proceeding, and held out his left hand, which was the nearest to the learned doctor. Dr. Philipson quickly corrected the mistake. and, taking the President by the right hand, led him forward, and the two bowed to the occupants of the three chairs.

Dr. Philipson then said: Mr. Sub-Warden and Proctors, I present to you Professor William Henry Flower, C.B., LL.D., F.R.C.S., F.R.S., the President of the British Association, to be admitted to the honorary degree of Doctor of Civil Law. This eminent naturalist is the director of the Natural History Department of the British Museum, the President of the Zoological Society, and one of the most distinguished anthropologists and biologists of the time. Professor Flower is the author of several most able works on anatomy, zoology, and the kindred sciences. In these he has traced the characteristics of mankind, and has won fame for the scientific world. It is very largely due to Professor Flower's well-directed labours that the Museum of the Royal College of Surgeons of London at present contains the most complete, the best ordered, and the most accessible collection of materials for the study of vertebrate structures extant.

The Sub-Warden shook hands with the President. and said : By the authority of the University, I admit you to be Doctor in Civil Law of this University. There are some honours, sir, which become doubly honourable from the industrious character of their recipients. It is peculiarly so in this instance. The University of Durham, in welcoming you and your learned coadjutors into the numbers of its most distinguished members, receives more distinction than it gives. We are proud to welcome you as a doctor of civil law. (Applause.)

Dr. Philipson then presented Sir F. J. Bramwell, in the following terms :—I present to you Sir Frederick Joseph Bramwell, D.C.L., F.R.S., the distinguished ex-President of the British Association, to be admitted to the honoary degree of Doctor of Civil Law. Sir Frederick Bramwell is a Past President of the Institution of Civil Engineers, also a Past Prime Warden of the Goldmiths' Company. He has rendered valuable service in the promotion of technical education, by the City and Guilds of London Institute. He acted as the chairman of the executive of the City Guilds, and guided their deliberations during the organisation of the system of classes and examinations, throughout the country, and the erection of the London Colleges. His name will be familiar, also, as associated with the Royal Institution and the Inventions Exhibition.

The Sub-Warden repeated the formula :—By the authority of the University, I admit you to be Doctor in Civil Law of this University.

Dr. Philipson proposed Professor Williamson, who was not present, and in doing so said :—I propose to you Professor Alexander William Williamson, Ph.D., LL.D., F.R.S., the general treasurer of the British Association, to be admitted to the honorary degree of Doctor of Civil Law. This illustrious chemist was formerly the Professor of Chemistry in University College, London. He is a Past President of the Chemical Society. Professor Williamson's researches on the Etherification exercised a considerable influence on the theories of chemical action, and have since been adopted by the chief English and foreign chemists. He is a member of the Senate of the University of London, and has taken an active part in promoting the establishment of degrees in science, in that University.

The House agreed to the admission of Professor Williamson.

Dr. Philipson then presented Sir Douglas Galton, as follows :—I present to you Capt. Sir Douglas Galton, K.C.B., D.C.L., LL.D., F.R.S., one of the general secretaries of the British Association, to be admitted to the honorary degree of Doctor of Civil Law. Sir Douglas Galton has rendered valuable service to the State by the improvements he has been instrumental in bringing about in the construction of hospitals. The institutions in which his recommendations have been adopted have been rendered safe havens of refuge for the afflicted. Sanitary science has been advanced by his official connexion with the Sanitary Institute of Great Britain. His name also will be favourably remembered as one of the founders of the Pakes Museum of Hygiene.

Sir. Douglas was admitted, like those who had gone before him.

Dr. PHILIPSON, in presenting Mr. A. G. Vernon Harcourt, said: I present to you Mr. Augustus Geo. Vernon Harcourt, M.A., LL.D., F.R.S., one of the general secretaries of the British Association, to be admitted to the honorary degree of Doctor of Civil Law. This cultured scientist is the Lea Reader in Chemistry at Christ Church, Oxford. Mr. Vernon Harcourt has rendered valuable aid in the development of the study of the Natural Sciences, in his own University of Oxford, and also, in the University of Cambridge, and in the Victoria University, Manchester.

Mr. Harcourt was formally admitted.

Canon TRISTRAM presented Sir F. de Winton, and said Sir Francis de Winton was the son of a Durham mother, of a family well-known and distinguished in that county. He took part gallantly in the great struggle of the Crimea, as his decorations and the letters attached to his name proved to them. He afterwards accompanied his friend Sir Frederick Williamson in his travels, and after that again he went with the Marquis of Lorne to assist him in the government of Canada. Then, after a moment's pause in his rapid career, in command of the military forces in the neighbouring city of Newcastle, he went out to the Congo, to replace the noble General Gordon, who had just been recalled thence by our then Government, to be left deserted by his countrymen at Khartoum. (Applause and hisses.) After three years as Administrator-General of the Congo, he was sent out in command of the force which suppressed the alarming rising on the Gold Coast. Thence he returned to his present high post at the Horse Guards. In concluding, Canon Tristram said: One of England's typical sons, in arms and arts alike, known, ready to do anything and to go anywhere for his country, whether to the forests of North America or to remain in the swamps of Central Africa, methinks, in attempting to do honour to Sir Francis de Winton, we of this university are rather doing honour to ourselves. (Applause.)

The SUB-WARDEN thereupon conferred upon Sir Francis de Winton the degree of D.C.L.

Principal GARNETT then introduced Captain W. de Abney, and said: Mr. Sub-Warden and proctors, I present to you Captain William de Abney, of the Corps of Royal Engineers, Companion of the Bath, Fellow of the Royal Society, to be admitted to the honorary degree of Doctor of Civil Law. Though military pursuits have not generally been regarded as conducive of scientific research, there is perhaps no other organised body to which we are so much indebted for scientific discovery and industrial progress as the corps of Royal Engineers. (Hear, hear.) The names of Clarke, Sabine, Sir Henry James, De Conray Scott, Stuart Wortley, Armstrong, Noble, Donelly, Festing, and many others, are well known. In captain Abney they find a worthy associate, one who is, in a special sense, a man of light and leading. In photography Captain Abney has long stood *facile princeps*. In this department he has led the way in reducing the science to an empirical art; to him we are indebted for the most careful measurements of the facts of light belonging to the different portions of the spectra upon a great variety of photographic materials, and for the discovery of the action of the infra red rays upon certain modifications of silver salts, as well as for many valuable processes in the valuable art. As Assistant-Director for Science, Captain Abney has, in conjunction with General Donelly, the guidance of scientific training of the many youths who attend our Government science classes, and in him this university may in some slight measure acknowledge the services which the Science and Art Department has rendered to scientific and industrial education. (Applause.)

Captain DE ABNEY received the degree.

Principal GARNETT introduced Professor James Geikie. He said: Mr. Sub-Warden and proctors, I present to you Professor James Geikie, Doctor of Laws, Fellow of the Royal Society of London and Edinburgh. Fellow of the Geological Society, and Murchison Professor of Geology in the University of Edinburgh, to be admitted to the honorary degree of Doctor of Civil Law. Having spent a considerale portion of his life as an officer of the Geological Survey, Professor James Geikie has acquired a thoroughly practical acquaintance with his subject, and his qualifications as a surveyor were publicly recognised when, in company with Sir Andrew Ramsay, he was entrusted with the survey of Malta. (Applause.) His text book on geology indicates that as a professor in the teaching university he is in his true sphere. His other writings give proof of his intimate acquaintance with the rocks of the carboniferous series and with the great ice age, on which he must be regarded as one of our greatest living authorities.

Professor GEIKIE was admitted.

Principal GARNETT, introducing Professor Edgeworth, said: I present to you Professor Francis Y. Edgeworth, Master of Arts, Fellow of the Statistical Society, to be admitted to the honorary degree of Doctor of Civil Law. It was the opinion of Pythagoras that nature was based upon number, and that the differences in things were due to the differences in the numbers upon which their structure was built. This modern Pythagoras—(laughter)—has taught us the value of numbers in our national, social, and commercial life. Statistics in most hands prove a dangerous weapon. Professor Edgeworth has reduced them to a science, and has shown us how to employ them in order to discover truth in its simplest forms. A classical scholar of the first class, he devoted himself to the study of mathematics, thus becoming first a "man" and then a mathematician. (Laughter.) And, as a result, he applied his mathematics to those social and economic questions which form so large a factor in a man's life—in particular to the investigation of the evidence of the truth of ghost stories. (Laughter.) His published works bespeak his merits; the services which in many public offices he has rendered to economic science demands our acknowledgment. (Applause.)

Professor Edgeworth received the degree.

Principal GARNETT, presenting Mr. William Anderson, said: I present to you Mr. William Anderson, a member of the Council of Civil Engineers, to be admitted to the honorary degree of Doctor of Civil Law. A man who, to use the words of Sir William Thomson, is the eminently scientific and eminently practical son of an old Newcastle family—a linguist, a chemist, a physicist, a mechanician, the president of the Mechanical Section of the British Association, has long been eminent as an engineer, having been President of the Institution of Civil Engineers of Ireland more than a quarter of a century ago; and as engineer of the Royal Agricultural Society he has done much towards bringing agricultural machinery to its present high state of development. Educated at St. Petersburg, in a school in which modern languages and science were the chief subjects of the curriculum, Mr. Anderson acquired an intimate knowledge of Russian, French, German, and English, and to this he attributes much of the success he has since achieved. Within the last few weeks his attainments have been specially recognised by her Majesty's Government, and he has been appointed Director-General of Ordnance Factories. (Applause.) In this capacity he will bring to the public service that scientific knowledge and those business qualifications which have placed the great firm of Easton and Anderson in the forefront of engineering enterprise. (Applause.)

Mr. Anderson was admitted.

Dr. PHILIPSON proposed Professor Burdon Sanderson, in his absence. He said: I propose to you Professor John Scott Burdon-Sanderson, M.A., M.D., LL.D., F.R.S., the president of the Section of Biology of the British Association, to be admitted to the honorary degree of Doctor of Civil Law. This renowned biologist is the Waynflete Professor of Physiology in the University of Oxford. He was formerly tho President Superintendent of the Brown Institution. Professor Burdon-Sanderson has devoted himself to physiology and experimental pathology, and is not less known as a pathologist than as a physiologist. Out of his study of comparative pathology has come that wide-spread knowledge of tho dependence of specific diseases upon minute organisms, the bacteria. The long list of papers which he has written is the record of a life faithfully devoted to science, and to the utilisation of the facts so obtained, for medical purposes.

Professor Burdon Sanderson was admitted by the voice of the House.

Dr. PHILIPSON, in presenting Sir W. Turner, said: I present to you Professor Sir William Turner, M.B., LL.D., F.R.S., the President of the Section of Anthropology of the British Association, to be admitted to the honorary degree of Doctor of Civil Law. This distinguished anthropologist is the professor of anatomy in the University of Edinburgh, and the professor of anatomy at the Royal Scottish Academy. He is a member of the General Medical Council, and an ex-President of the Royal College of Surgeons of Edinburgh. Professor Turner is the author of many works on the anatomy and histology of man and the lower animals. The monograph on the human crania brought home by the "Challenger" expedition is from his hand, a work which forms one of the most important contributions to anthropological literature that has appeared.

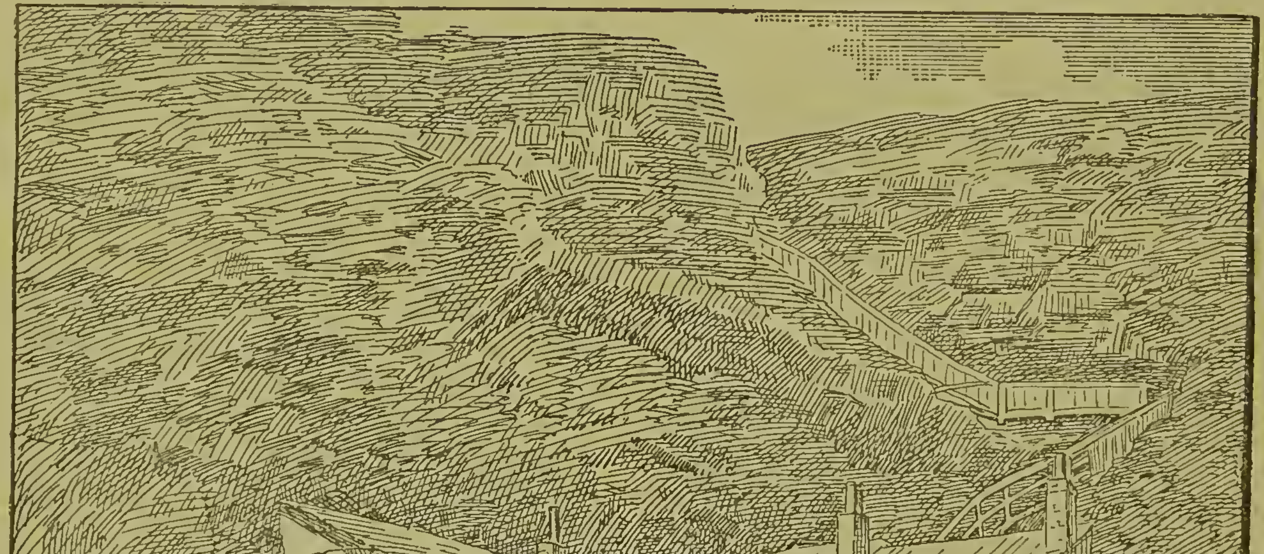
Sir W. Turner was admitted.

The SUB-WARDEN said: No other names will be submitted to this convocation, not for lack of material—for we see all round us men whose names are most distinguished and well known to the whole world—but in this case the university has desired to acknowledge the British Association as a body, and has therefore requested that they might do themselves the honour of conferring upon the officers of that Association the highest degree it was in their power to grant. The convocation is dissolved.

A service was afterwards held in the cathedral, and subsequently Canon Greenwell gave a historical description of the ancient building. At the old castle there were numerous visitors, and descriptions were given of it by members of the council of the university. Altogether a very profitable and agreeable afternoon was spent by the excursionists.

MARSDEN.

About fifty ladies and gentlemen, several of whom were interested in geology, availed themselves of the excursion to Marsden on Saturday afternoon. They left Newcastle in the ordinary train, at 1·15 p.m., and, on arriving at the South Shields terminus, walked to the Westoe Lane station of the Whitburn Coal Company's railway, where a special train was in waiting. By this train they were conveyed to Marsden, a splendid view of the coast and the estuary of the Tyne being seen *en route*. The atmosphere was dry and clear, though somewhat chilly; and the trip to the seaside was evidently such as to afford pleasure to the visitors. The conductors of the excursion were Messrs. John Daglish, R. Howse, and E. J. Garwood. These gentlemen had arranged for a visit, in the first place, to the colliery, then to the limestone quarries, and finally to the celebrated Marsden Grotto. Mr. Daglish assumed the duties of *cicerone*, and conducted the party to the pit head, where the working of the cages in the shaft was seen in operation, and the means for preventing over-winding explained. The cleaning of the coals by the belt-screen system attracted a good deal of attention. This method of screening is not yet in general use, but is being adopted by other collieries in the neighbourhood. The large and powerful engines for working the cages and for ventilating the mine were seen in motion, after which a visit to the lamp room terminated the inspection at the colliery. The party next proceeded to the limestone quarries, about a mile to the north-west, and it was here that the geologists were able to thoroughly interest themselves. Some of the more enthusiastic of the party had provided themselves with



MARSDEN GROTTO.

satchels and hammers and before leaving had collected numerous specimens of various kinds of stone. The formation of the different strata was clearly seen in the parts where the stone was being quarried, and the machinery for blasting and dressing the stone was observed in actual operation. From the quarries a move was made direct to the Grotto, where the former habitation of the famous Peter Allen furnished an interesting termination to a very pleasant afternoon's ramble. Here the party made a close inspection of the excavations in the cliff, and were deeply interested in the caved Marsden Rock, which was at the time surrounded by the tide, as well as in the other attractions of the place. The aspect seaward, also, was full of pleasure and interest to the visitors. Many large steamers were passing to and fro close inshore, and there was just a sufficient ground swell to give that heaving and rolling motion which is so pleasant to look upon. By the kind hospitality of Mr. Daglish, the visitors were entertained to tea in the Grotto. A very excellent repast was provided, and, served practically in the open air, with a full view seaward, the meal was discussed with apparent heartiness by one and all. At the conclusion, Mr. Morris proposed a vote of thanks to Mr. Daglish for having provided the entertainment. He remarked that he had attended meetings of the British Association in all parts of England, Scotland, and Ireland, and that he had always found the hospitality in the North was warmer and better than it was in the South. He called for three cheers for Messrs. Daglish, Howse, ahd Garwood. A hearty response having been given, Mr. J. E. Marr, of St. John's College, Cambridge, seconded the proposition, which was carried with enthusiasm.—Mr. Daglish, in returning thanks, said there had been many gatherings of a similar kind at Marsden, and that the magnesian limestone of that district had always had an interest—possibly from its close proximity to the grotto—(laughter)—in drawing geologists together. He might say that at the last meeting of the British Association in Newcastle, in conjunction with the late Mr. Clapham, he read a paper on the minerals found in connexion with the coal measures, and introduced the subject connected with that stone. They had discovered certain small nodules, and found them to be pure carbonate of lime, and thought it worthy of notice in the papers. They might have analysed the whole of those rocks with the same result. All that quarry was pure carbonate of lime, with just a trace of magnesia. The feature of special interest they had seen at the pit was the belt system of screening coals, which, although not absolutely novel, was of recent introduction, and very much facilitated the cleaning of coals, and enabled the work to be done economically. Another interesting feature was the winding engine for drawing coals out of the pit. It was one of the four largest in England—two others being at Silksworth, and one at Harton. (Applause.)—Mr. Howse also responded to the toast, and said if the visitors would kindly look into the Newcastle Museum he would have great pleasure in showing them the peculiar features of the limestone found in the county of Durham. He regretted that English geologists as a rule almost entirely ignored the Permian limestone and its fossils. Just below the magnesian limestone they had found remains of the oldest reptiles known in the geological series.—Mr. Garwood having briefly returned thanks, the party again separated.—The train afterwards took the visitors to Shields, and thence to Newcastle, which was reached shortly after eight o'clock.

BYWELL AND PRUDHOE.

A party of some twenty-five ladies and gentlemen—members of the British Association the gentlemen, and the ladies associates—took train on Saturday afternoon to Stocksfield station, wishful after the scientific diet of the previous few days to taste somewhat of our North-Country fresh air, to drink in some of its scenery, and to sip from the well-nigh inexhaustible fountain of its antiquities and historical remains. For guides they were excellently supplied, for few could have better shown them what to see, how to see it, and in as great a degree as possible how to appreciate what they saw than Mr. C. J. Bates, the Rev. A. Johnson, and Mr. W. W. Tomlinson. Those who chose this of the many attractive excursions provided to select from were Mr. J. M. Meek, Mr. J. G. Dickinson, Mr. Rupert Swindells, Mr. C. E. P. Wellington, Miss Lydia Becker, Mrs. Hodge, Mrs. Perrin, Mr. H. S. Perrin, Mr. and Mrs. Mark Stirrup, Mr. and Mrs. J. Sargent Stacy, Mr. Bryan Corcoran, Mr. F. J. Faraday, Mrs. White, Mr. Henry Paton, Miss Scott, Miss E. Scott, Mr. Harvey Scott, Mrs. Thomas Hewson, Mr. Thomas Hewson, and Mr. D. Howard. At Bywell they were met by the Rev. A. Johnson, Vicar of Healey, and Mr. W. W. Tomlinson, and afterwards by the Rev. H. Slater, Vicar of Bywell St. Andrew's, and later still by the Rev. Canon Dwarris, Vicar of Bywell St. Peter's, as well as by Mr. Geo. A. Fenwick, of Bywell Hall, and Mr. John Hall, of Bywell Tower. At Prudhoe Mr. C. J. Bates joined them, and at Ovingham Church they were received by the Rev. C. E. Blackett Ord.

No kinder, more hospitable reception could any party of strangers possibly have had than they got at the hands of these gentlemen, and, if their visit to the North do them no more good, it must at least have proved to them convincingly the warmness and cordiality of our Tyneside gentry. For they were conducted round the lovely district they had come to see in a most energetic fashion, and there was nothing lacking on the part of those who knew and loved that country side to enable those who now saw it for the first time to taste of the enjoyment so plentifully to be had on all sides; whilst time was the only thing lacking to enable the visitors to enter into the spirit of what they saw and heard.

As has been stated, the trip was a new one to all but a very small proportion of those who formed the party, most of them coming from the furthest South of England; and many were the exclamations of surprise that our reputed bleak and barren North-Country could contain such scenery and such remains of deepest historical interest as they then witnessed. And pity it was that some one had not told them aught of the beauties of Tyneside, and taught them even a little of what had passed in the brave days of old in the smiling valley where they stood. For themselves they saw a noble river in a charming country, pleasantly diversified with hill and dale and embellished by a luxurious and profuse green wood, whose foliage advancing October was mellowing from afar, the yellow leaf and the red giving token of the ripe autumn. They could not picture behind the hills on the north that wonderful Roman Wall which is at once one of the most ancient and one of the most interesting relics of early civilised Britain. They could not fully realise that turbulent past when all around them was war and tumult and spoil. Nor had they any idea of wild fells impressive in their extent and grandeur of barrenness, nor suspect that hidden amongst them was such a lovely vale as that of the Derwent with its secluded Blanchland, and the dale of the Allen further west, losing itself in the mountains. No, not even what they saw with their eyes and heard with their ears were they ready to understand to the full. Competent antiquaries poured out for their delectation a wealth of local lore, and it must be said that they had without exception most attentive, intelligent listeners. But even that small field of exploration was too great for them. The two venerable old churches of Bywell, the fine modern mansion and grounds of Mr. Fenwick, the picturesquely situated ruins in the midst of which Mr. John Hall is fortunate enough to live, the stately pile that still tells, despite the run of centuries, of the majesty of Prudhoe Castle, and the ancient stones of Ovingham Church, first masoned when England was still a sapling—these were too much for one short afternoon. The official guide book told them something of the two ancient and beautiful churches, of the still splendid remains of the Castle, and of the almost prehistoric mote hill of Bywell;

and the Rev. A. Jones read two able and interesting papers on the ecclesiastical and military history of the place. Mr. C. J. Bates most ably and eloquently descanted on the beauties of the Percies' castle at Prudhoe, and Mr. Tomlinson and Mr. Blackett Ord led a still enthusiastic throng of inquirers about the interior and precincts of the church across the water, doing their best to dispel with candle-light and the flicker of the taper the darkness that had closed in on all around.

Here was a wealth of old associations that the hurried chat of a few hours could not by any possibility do justice to. Our most learned antiquaries themselves, men who have given a lifetime of study to it, are puzzled by the archæology of this little bit of Tyneside. Many differ in opinion, think this and opine that; but none knows. This is the country not set down in the Domesday Book. The Saxons who built these castles, the Northmen who conquered and dislodged them are unknown to us, and the deeds of the men who built the mighty strongholds live only in the *débris* and the patched up walls that the Normans found ready made for their habitation. No real Percy had ever anything to do with the building of the castle which gave his baronial name to the fourth of the present ducal line of Northumberland. Prudhoe Castle stood before the Karling Percies came to Northumberland. As at Alnwick, as at Warkworth, so at Prudhoe. The Percy of the true line never was there. The ruins of Prudhoe Castle hold a situation unsurpassed on the Tyne. Its barbican is the idol of the archæologist, the ruins round the court-yard indicate how great its former size, and the massive keep, still proud and grand, though shattered, bears witness to its ancient strength, which withstood the Scots when Warkworth fell before them. There Odenell of Umfraville kept at bay the host of the northern king, and the invaders could do no further damage than peel off the bark from the apple trees in the orchard. Ovingham Church, too, one of the purest præ-Norman Romanesque buildings in the country, recalling Monkwearmouth, carries us back to the days of the old sagas, when Bernicia led the rest of England in learning and poetry.

Little of this was said on Saturday; nor did the guide-book tell it. Time did not allow of the slightest diversion, even though it led to the very heart and soul of the history of these fine old buildings. The guide-book was a string of names and dates, as complete and comprehensive as possible, but bald and artificially dovetailed together. The guides, excellent as they were, and full of knowledge, had to deal with the bare, cold stones, and the styles of the carvings, this curious inscription, that interesting oriel window, the first built in England (in Prudhoe Castle), the beauty of the columns, and all the details of architecture, as well as the contradictions of chroniclers and the theories of antiquaries—in short, they had to make the most of their time in putting as many interesting and curious particulars before their audience as possible, and, if they failed in point of completeness, and in enabling their hearers to carry away a broad grasp of the subject, it was not their fault, and was not, indeed, a thing to be expected.

From the theories of philosophers, the tedium of terminology, and the dreariness of dry as dustness the strangers had a brief respite, during which they betook themselves to the country for fresh air, cheering prospects, ' and mental and imaginative recreation. Those who went to Bywell and Prudhoe got all this and more. and there was not one who did not thoroughly enjoy it. Whilst the several gentlemen were enjoying the beautiful view of the river from the summer-house in Mr. John Hall's grounds, they enjoyed the unusual spectacle of a kingfisher of splendid plumage, the bird making a long flight across the old salmon weir. One of the most graceful incidents of the trip was the most characteristic exhibition of Tyneside *bonhommie* and open hospitality towards the strangers who have come in part for a holiday and to see our countryside, by two gentlemen whom Newcastle is proud to number amongst its best citizens—Mr. George Fenwick and Mr. John Hall. To local readers these gentlemen are well known for their liberality, and the way in which they most kindly opened the privacy of their grounds and spread the luxuries of the table before their scientific visitors and their friends was deserving of the highest praise. This, it must be stated, was most cordially appreciated by the party, who were of such a sort as to understand thoroughly how well they had been treated, and into what pleasant places their lines had fallen.

DILSTON AND AYDON CASTLE.

The excursionists for Dilston and Aydon Castle left by the 1·25 special train. About fifty ladies and gentlemen alighted from the train at Corbridge, amongst those present being Professor Oliver, Professor Faraday Spence, Dr. and Mrs. Gibson, of Tynemouth; Mrs. R. S. and the Misses Watson, Mr. S. R. Atkins, J.P., of Salisbury; Mr. H. Bauerman, of London; Mr. H. R. Proctor, of Tynemouth; Mr. W. H. Harrison, editor of the *Photographic News*; Mr. M. C. Masterman, of South Shields; the Rev. Mr. Carr, the Rev. Jas. Steel, of Heworth; and others. The party divided itself—one-half going to Aydon Castle and the other half going to Dilston Castle. The company for Dilston proceeded by the footpath skirting the railway, through fields, and entered the grounds near the old disused flour-mill. Mr. J. Balden, jun., here assumed the lead, and conducted the party to the remains of the pillar of an old bridge which stands between the Devilswater and the east side of the mill. Antiquaries are in some doubt as to whether the structure is Roman or Norman, but that it was a pack-horse bridge, as its width would not allow a carriage to pass over, the majority agree. In support of the opinion that the bridge was Roman, stones bearing traces of Roman masonry were pointed out in the foundations of the old mill. The party then proceeded up the side of the stream to the small stone bridge which, surrounded by a wealth of variegated foliage, and overlooking the Devilswater purling lazily along its rocky bed, has been immortalised by the brushes of the Richardsons, Barmer, Martin, and other artists of North-country fame. After passing through the scene, which was much admired, the guide led the way up one of the steep roads to the old castle, which was shortly after entered. Visitors to the spot a few years ago will remember the crumbling appearance of the ruin, and the risk to life and limb one ran in attempting to obtain a view from the top of the tower. Recently Mr. W. B. Beaumont, M.P., the owner of the estate, has strengthened the ruin, and has made the tower easy of access. After viewing the rooms on the ground floor, the company entered the principal room on the first floor, where Mr. Balden read a paper by Mr. R. O. Heslop, of Corbridge, on the history of Dilston. After pointing out that Dilston is the shortened form of Devilston, that is the "ton" or town of Devilswater, and that the place-name gave the patronymic to the family who first possessed the manor, the author proceeded to quote the original grant, preserved with the Dean and Chapter monuments at Durham, of Prince Henry, the son of David, King of Scotland as follows:—"Henry, son of the King of Scots, to the Bishop of Durham, to the justices, sheriffs, barons, ministers, and to all his faithful French and English throughout Northumberland, as well present as future, health. Know ye that I have granted and assigned to William, the son of Alfric, of Corbridge, the land of Richard, his brother, of Devilston." In a second document Henry II. of England, who had possessed himself of the earldom of Northumberland, ratifies the grant in almost identical terms. William, son of Alfric, is thenceforth known as William de Devilston, progenitor of the family which became a prominent one during two centuries. Between 1172 and 1177 the great keep at Newcastle was in progress, and during the last two years of the building Robert de Devilston was one of the inspectors of works there.

The line appears to have failed early in the reign of

Edward III., and in 1358 Edward granted license, in consideration of 20 marks, to William de Tyndale, to enfeoff the manor of Devilston. From William the estates passed to a nephew, Walter, who left two daughters. The younger of these survived, and married Richard de Craster, but had no issue. Her cousin and heir, Sir William de Clayton, then entered upon the estates. Attempt was made to oust him from the place by an armed force, who acted under the support of the Earl of Northumberland, and a person of the name of John Fitz-a-Jolyial was put in possession. The incident is narrated in a petition from Sir William de Clayton to Parliament. In 1454, Robert Clayton, knight, was possessed of the manor and vale of Dilston. Johanna, daughter of Sir Robert Clayton, married John Cartington, of Cartington, to whom she brought as dower the manor of Dilston and other possessions. Their daughter and heiress was Anne Cartington, who married Sir Edward Radcliffe, of Derwentwater, who was still living in 1511. Over a gateway, about thirty yards from the ruin, and which the guide pointed out, are carved the initials F R—I R—1616, and they probably indicate the date of the transference of the manor to the Derwentwater family by Sir Francis Radcliffe. The next baronet, Sir Edward, died in 1652. In 1621, he had, during his father's lifetime, contracted for large additions to the mansion. His vast estates were forfeited for the part he took as a Royalist, but were restored shortly before his death by the restored monarch. His successor, Sir Francis, negotiated a marriage for his son Edward with Mary Tudor, an illegitimate daughter of Charles II., and was created Earl of Derwentwater in 1688. He died in 1696. Edward, the second earl, died in 1705, and was succeeded by James, third and last earl, then a lad of 16, cousin and companion of the young Pretender. It is to the history of the last earl that Dilston owes its peculiar interest. In the North the earl has been an idealised personage in the affections of the people, and in song and legend his memory yet lives. "Since the blotting out of the great house of Neville, of Raby," says Mr. Longstaffe, "by a treason as crude and incapable of success as that of 1715, no family has even to the present day, so firm a hold upon the affections of the natives of ancient Northumbria as that of the Radcliffes. They fell before a general change of manners took place, before the exchange of old hospitality and patronage on one side, and of deferential respect on the other, gave way to greater coldness, but more sturdy independence on both. Therefore, the memories attached to Dilston in the feelings give rise to more than affection for an amiable family and appreciation of mistaken devotedness to the cause of a line which was supposed to possess hereditary rights to the Crown. They arise also in the glowing colours which attach to an obsolete state of society, as to all departed things, in total forgetfulness of the defects which, while the now lamented part was a matter of present contemplation, showed that the heart of man was foolish and evil continually."

The last earl was executed on Tower Hill, in February, 1716, and the castle afterwards destroyed. What was left was in 1765 ordered to be sold by the Commissioners of Greenwich Hospital, to whom the estates had been given. The contents of the hall were scattered about and hoarded as relics, and the stones of the castle were sold for building material. Radcliffe House, the residence of Professor Lebour, and many other houses in Corbridge were erected from the stones obtained at Dilston. What is left is a most picturesque portion of the structure. It appears to be of various periods, the ancient foundations having been used for later buildings, and these in turn having been modified down to the time of occupation by its last tenant. The estate was purchased in 1874 by Mr. Beaumont, and the work of restoration has been carried out by Mr. Balden, Mr. Beaumont's resident agent. In 1857 the estates were claimed by a lady who styled herself Amelia, Countess of Derwentwater. The guide pointed out the room, adjoining the drawing room, in which her "ladyship" took up her abode when pressing her claim in 1868. This lady submitted six documents, including wills and deeds, in support of her claim and she had a large number of relics which belonged to the family. The story of the relics is that the countess of James, Earl of Derwentwater, removed a quantity of valuable plate, jewellery, pictures, furniture, &c., while the earl lay in the Tower. When she took up her residence at Louvaine (where she died in 1723), these relics were conveyed for shipment at Newcastle, but when war broke out between France and Germany, towards the close of the last century, these interesting memorials were placed for security in a secret vault in Hesse Darmstadt. "Lady Amelia," by permission of the authorities of Hesse Darmstadt, had the greater portion of the relics removed to Blaydon, fortunately just in time, to prevent their capture by the Prussians. In 1864, the claimant took up her residence in Blaydon, where she rallied to her cause a number of friends, some of whom attested their faith in her case by larger or smaller contributions of funds for the purpose of substantiating her rights in the courts of law. In the autumn of 1868 she suddenly left Blaydon with the bulk of her curious goods and chattels, and took formal possession of Dilston Castle. Her "ladyship" was dressed in the Austrian military uniform, and wore a sword by her side in the most approved fashion. In the course of a few hours she was visited by Mr. C. G. Grey, the receiver of the Greenwich Hospital Estates, who informed her that she was trespassing upon the property of the commissioners. She replied that she was acting under the advice of her legal advisers. The sides of the principal room were hung with the Derwentwater family pictures, and the old baronial flag of the family floated from the summit of the tower. A window or two were stopped up with bundles of straw, and others covered with old canvas. There was no roof, and how the "countess" remained there with no protection, and without a single lady attendant, was a mystery to everyone. Ultimately the claimant was "ejected" from the castle on to the highway, where, with assistance, she erected a kind of camp. Thus matters went on for some weeks, and she was eventually expelled from the high-road by the magistrates. Pecuniary embarrasments accumulated around her, and those who had advanced money became pressing. In 1873 she was a prisoner in Newcastle Gaol under an order of the County Court. Her last days were spent in extreme poverty.

The party were afterwards shown the chapel, which adjoins the hall, in whose vaults the last earl and other members of the family were buried. In consequence of the vault being broken open, and "relics" taken from the coffins, the bodies were removed to the Roman Catholic chapel at Hexham—the body of the last earl being taken to the burial place of Lord Petre, at Thorndon, in Essex. After walking through the beautiful grounds the party walked back by the plantation on the bank of the Tyne, and viewed the foundations of the Roman Bridge. The company afterwards sat down to tea in Corbridge.

The party for Aydon Castle was conducted by Mr. R. O. Heslop, of Corbridge, who led the way from Corbridge Station across the Tyne to Corbridge, and then by road and bridle path to Aydon Castle. On the way to Aydon, where the bridle path leaves the main road, the guide directed attention to a relic of the ancient "openfield" method of cultivation (which prevailed in England up to the enclosure of the "common lands"). It consisted of a two-acre field divided into four distinct strips, each separately cultivated, and divided from its neighbour by a thin "balk" of unploughed turf. Trees of "terrace cultivation" were also seen on the neighbouring slopes. Farther on a splendid view of the surrounding country was obtained, and Mr. Heslop pointed out the Roman Wall, Hexhamshire, the Devilswater, and other places of interest. The party descended into the Dene, and passed round to the front of the castle, which was then inspected by the party. Aydon Castle dates from 1305, when it was built by Robert de Reymes. The castle was taken by King David of Scotland in 1346, when on the expedition which ended at Neville's Cross. The castle, after belonging to the families of Ramsay and Carnaby, was purchased in 1706 by John Douglass, of Newcastle, through whose heiress it passed into the Blackett family, the present owner being General Sir Edward Blackett. The castle is of considerable extent, and in some respects unique. The outer and inner baileys retain their walls. The walls of the inner bailey are in perfect preservation, and occupy two sides of the quadrangle, which is completed by the main building. A fine outside staircase leads to the principal rooms which present many points of interest. There are several very early original windows and fireplaces, which give a special character and interest to the building; whilst the setting of this fortified mansion, with its precipitous face half encircled by a typical Northumbrian dene, adds a feature of singular beauty to the site.

The company then retraced their steps to Corbridge where tea was partaken of in the Town Hall. After tea, a hearty vote of thanks was accorded to the guide, Mr. Heslop, who briefly returned thanks. Mr. Heslop then conducted the Dilston and Aydon parties over the town and parish church. He stated that Corbridge was a border town of considerable importance in early historic times. In 786 A.D. Adulf of Lichfield was consecrated Bishop of Corbridge, and the town was a royal residence in Saxon times. The parish church of St. Andrew presents a unique epitome of the story of the burgh of Corbridge. The tower is of pre-Norman Romanesque style, and is believed from its detail to belong to the same period of church building as the ancient monastic church of Monkwearmouth in Durham. The Saxon church of Corbridge was about 52 feet long by 23 feet broad outside, and 52 feet high. The pele tower in the churchyard was also inspected. It is mentioned in the list of castles and fortresses in Northumberland in 1415 as the "Turris de Corbrigge." The tower at the extreme end of the village was visited earlier in the day. The company then returned to Newcastle. after spending an enjoyable day in the district of Corbridge. We must not omit to mention that the ladies of Corbridge waited upon the visitors at tea, and that they were warmly thanked for their valuable and kind attention.

THE ELSWICK WORKS.

The visit of the British Association to Newcastle would have been incomplete had the Elswick Works not been thrown open to the inspection of the members. Lord Armstrong and the directors generally are always ready to open their works to distinguished strangers and members of scientific bodies, and the officials, from the highest to the lowest, appear to take a genuine pleasure on these occasions in pointing out and describing what is most noteworthy. Saturday afternoon, between the hours of one and five, was the time appointed for the visit to the works by our scientific visitors, and, in spite of strong attractions elsewhere, a large number of the wise men made their way to the Elswick arsenal. While some hundreds preferred to breathe the air of the country in connexion with the various excursions, and many others went to witness the interesting proceedings at the neighbouring city of Durham, a large section to the number of about 200, took advantage of the offer of the Elswick firm to view the wonders to be seen in the great workshop. Nor were the members of the British Association alone, for their number was augmented by the members of the Newcastle Association of Foremen Engineers and Draughtsmen, and also a large contingent of gentlemen of the same calling from Sunderland. Amongst those present were :—Mr. Patrick Y. Alexander, Bath; Dr. J. R. Leeson, C.M., F.G.C., Twickenham; Mr. J. C. Haworth, Manchester; Dr. John Rae, London; Mr. Charles Hansford, Dorchester; Mr. Robert Millar, Musselburgh; Prof. J. A. Ewing, University College, Dundee; Prof. Perry, F.R.S., London; Mr. W. Dunlop, Calcutta; Mr. R. Routledge, North-Eastern Railway Company, Gateshead; Mr. L. R. Wilberforce, Trinity College, Cambridge; Mr. W. Dalrymple, Gateshead (secretary of the Newcastle Association of Foremen Engineers and Draughtsmen); Mr. James Swinburne, Wimbledon; Mr. W. Whitaker, Southampton; Mr. J. Bowman, Victoria, Australia; Dr. E. Cutter, New York; Major Burge, Barracks, Newcastle; Mr. Saville Shaw, Manchester; Mr. William Munro, Edinburgh; Mr. F. B. Garnett, C.B., London; Mr. Arnold J. Wallis, Cambridge; Dr. J. L. Howard, University College, Liverpool; Mr. C. Michio Smith, Madras, India; Mr. A. H. L. Newstead, Christ's College, Cambridge; Mr. A. A. Paekard, Providence, U.S.A.; Mr. W. H. Symons, F.C.S., London; Mr. R. Gruneberg, Cologne; Mr. R. Millar, C.A., Edinburgh; Mr. J. Wetzler, New York; M. A. Gobert, Brussels; Mr. Llewellyn N. Tyzack, University College, Bristol; Professor Liveing, Cambridge; Mr. Thomas Turner, Mason College, Birmingham; Mr. T. Howell Williams, London; Mr. R. S. Cole, Emmanuel College, Cambridge; Professor Bower, Glasgow; Mr. Ralph Copeland, Astronomer Royal for Scotland; Lieutenant-Colonel Sir R. F. Playfair, H.M. Consul, Algiers; Mr. Gilbert J. Fowler, Manchester; Mr. W. F. Stanley, London, &c. The foremen of the works had kindly volunteered to show visitors around the shops, and, parties of about ten gentlemen each being formed, the different objects of interest were explained to them very easily. We have had occasion so frequently to describe what is to be seen in the Elswick Works that a passing reference to the principal sights witnessed by the members of the British Association on Saturday will suffice. In the engine works there was shown the new bridge yard where dock gates and the frames of gun carriages are built, as well as the erecting shop for cranes, the erecting shops for steam and hydraulic engines, and other departments. Interesting as the engine works always are, the ordnance works are usually the strongest attraction; and this was the case on Saturday. The heavy gun machinery interested the spectators greatly. Here were the heavy guns built for our own and foreign Governments, huge weapons of 105 tons being in course of construction. The breech mechanism for a 105 ton gun and cradles for the 4·7 inch and 6 inch quick-firing guns—the latest, and in many respects the most successful product of Elswick—were duly noted. There were many specimens of the 4·7 and 6 inch quick-firing gun, these being destined to form the principal minor armament of the ships under the new naval programme. These guns fired projectiles of 45lbs. and 100lbs. respectively. The rapidity with which the guns fire is about five or six times that of the service guns of similar calibre. The 45-pounder will fire from ten to twelve shots per minute with ease, whereas the service 5-inch breech-loader gun fires only from one to two in the same time. In the shop for finishing guns up to six inches there was also much to arrest the attention of the visitors, and in the carriage shops there were examples of the 6-inch hydro-pneumatic gun carriages. The shops for the following purposes were also inspected :—Shop for guns of the largest calibre, shop for building carriages and turrets, another shop for turrets, shop for gun and carriage work, the foundry, gun shrinking pit, and store. As the visitors completed their tour they made their exit by the blast-furnace gates. Visitors kept arriving until four o'clock, and it was nearly six o'clock before every one who wished to do so had been shown round. On every side were heard expressions of wonderment and delight, and there can be no doubt that the visit to the works gave more than satisfaction to those who went through them.

DOWN THE RIVER.

The excursion down the river is as popular with visitors to the Tyne as that commonly called "doon the watter" is with visitors to the Clyde. A large contingent of members and associates of the British Association, therefore, availed themselves of the offer of the River Tyne Commissioners, and enjoyed a trip down the river on Saturday.

The steamer J. C. Stevenson had, therefore, a goodly company on board, who were welcomed by Mr. Stevenson, M.P., the chairman of the Commission, Mr. P. J. Messent, C.E., and others, and, attended by the steam launch Lynx, the party left the Fish Quay with tolerable punctuality. Steaming up the river, the guests had pointed out to them as prominent objects in passing the old Mansion House, which for fifty years has fallen from its original use; the large flour mills that abut on the stream, and the historic locomotive works of Robert Stephenson and Co.; and the Shot Tower that has been long a landmark on Tyneside. A little later the long frontage of the Elswick Works was reached, and the shipyard attracted interest, as well as other portions of the establishment. Passing on until near to Scotswood Bridge, the stem of the boat was pointed down stream, and Derwenthaugh with its coke ovens attract the eye to the south side; then Dunston shows its front, and the huge flour mill is seen to be progressing there. From this point downwards for miles both sides of the river present an industrial picture such as few of our rivers can rival in variety and extent, and probably none can surpass. From the Italian cruiser in mid-stream to the firebrick works that spread their products on the quay, there is such an array of establishments producing chemicals and cement, coals and coke, grindstones and grates, soap and soda, engines and earthenware, ships, shot, and slag, as gives rise to astonishment on the part of those who have hitherto allied the Tyne with one great industry—coal—but still one that is only one of a cluster. Here are the gasworks which supply 30,000 customers through close upon 500 miles of mains, with the product of nearly 4,000 tons of coal weekly. There are the primal locomotive-building works in the world, and they and their Tyneside rivals now produce on the average more than three weekly, though the industry is not here what it was. And now we have two bridges before us and one behind, that compel the visitors to ask, and to learn that that behind us has associated with it the name of Sir Thomas Bouch; that that in front has the still higher-famed Stephenson as its designer; whilst the Swing Bridge, just beyond, has it opening part quickly swung at our approach, and its 1,450 tons are in a fraction less than 2¼ minutes turned to allow of the passage of the steamer, amidst the interested timing of several of the savants.

As the party came abreast of the Quayside, with its varied craft, erections and buildings, the Royal Dane was ready to leave for London, and others of the Tyne Steam Shipping Company's fleet for Continental ports. The grain warehouse was closed on Saturday afternoon. The quaint old dwellings that struggle up the riverside, and tell the tale of olden Newcastle, were scanned. The Durham side then projected chains, chemicals, and cement into the view, and the visitors learnt that 3,000 tons weekly of the latter are being turned out on the Tyne, and that for the alkali trade as large a quantity of salt is brought from South Durham. As the steamer gathered speed now, they passed rapidly chemical manure works, small "hards," and gridirons that were eloquent of the time when wooden vessels were more numerous; and one or two olden factories that were closed pointed the moral of the decay of industries that have been supplanted. The first of the shipbuilding yards on the south side had its three vessels on the stocks; and when they reached the last they learnt that over 54 vessels were on these building berths—a fact that spoke of full work for shipbuilders, but did not promise well for shipowners. Approaching Walker, its furnaces seemed to be temporarily idle, though the three shipyards near contribute their full quota to the Tyne's output, and that of Wigham Richardson had one near with the clipper bow that well-known shipbuilder likes. The middle reach of the Tyne, from Walker to Whitehill Point, was one of its most industrial portions, whilst a steamer fresh from Huelva spoke of an industry not yet named—that of copper—which is important, and has in it the seeds of growth.

Hebburn was passed, with its shipyards and chemical works, and at Jarrow there were only the two names on every tongue—of Bede in the past and Palmer in the present; and, though the clang of the riveters was silent, there was from blast furnace and mill a cloud of smoke that wreathed itself over town and river, and spread across Jarrow slake. Opposite this the first of the docks on Tyneside was seen; then opposite was the famous Tyne Dock, from which more coal is sent than from any other dock in the world. When South Shields was crowding down to the river side they turned to the north and glanced at the lock of the Albert Edward Dock, that could do with much more trade than it has. Through Shields Harbour, the steamer passed to where the first swell of the North Sea was felt, and slowly crossed to the north breakwater to allow the lowering and raising of a block to be effected by the mammoth crane, and then the Forester lifeboat, with its crew equipped for service, turned the thoughts, and prepared the visitors for that most interesting sight seen, after landing, from the breakwater—the practice with line and rocket of the noble life brigade.

The inspection of the manufacture of the blocks followed, and the details of construction were clearly stated by Mr. Messent, whilst the inspection of the large model of the piers aided in conveying to the visitors a full knowledge of the method of producing and laying them. The following statement by Mr. Messent, C.E., will sufficiently convey the idea of the method and result of construction:—

The piers, as designed by the late Mr. Walker, were commenced in 1856 (under the superintendence of Mr. Messent, as resident engineer) at each side of the entrance to the river, for the protection of vessels from the prevalent and destructive gales, varying from north-east to south-east, and for facilitating the removal of the bar. They are formed each of a base of rubble stone, deposited by barges, and a superstructure of concrete and built stonework, the lower and larger portions of which, commencing at 26 feet below water are fixed by divers. The length at high water line of the superstructure of the north pier completed is 2,952 feet, beyond which the submerged base extends about 235 feet. The length of the superstructure of the south pier completed is 5,218 feet, the submerged base being about 130 feet in advance. Nearly 3,000,000 tons of stone, exclusive of lime and cement, have, up to the present time, been used in these works, the construction of which, from their exposed position and frequent interruptions by storms and rough seas, is attended with great difficulty. A mammoth crane, designed by Mr. P. J. Messent, for extending the masonry superstructure of the piers without staging, was erected on the north pier in 1883, and a similar one on the south pier in 1884. These cranes (the largest yet constructed) are capable of setting blocks upwards of 40 tons weight at a distance or overhang of 75 feet beyond the supporting wheels, or in a radius of 92 feet from centre pivot. As evidence of the advantage of these works, coupled with the removal of the bar (which the construction of the piers rendered practicable) may be mentioned the large use of the port as a harbour of refuge, 515 vessels bound to other ports having safely entered the Tyne for refuge in one year, in addition to a large number of loaded vessels put back for shelter after leaving the Tyne. To this it only needs to be added that the visitors on Saturday had full opportunity to appreciate the results of the work on the Tyne in the last three decades. At almost all states of the tide the largest ships may enter the Tyne; and whilst much work has been done, more is being done at Whitehill Point, and in other sections of the river.

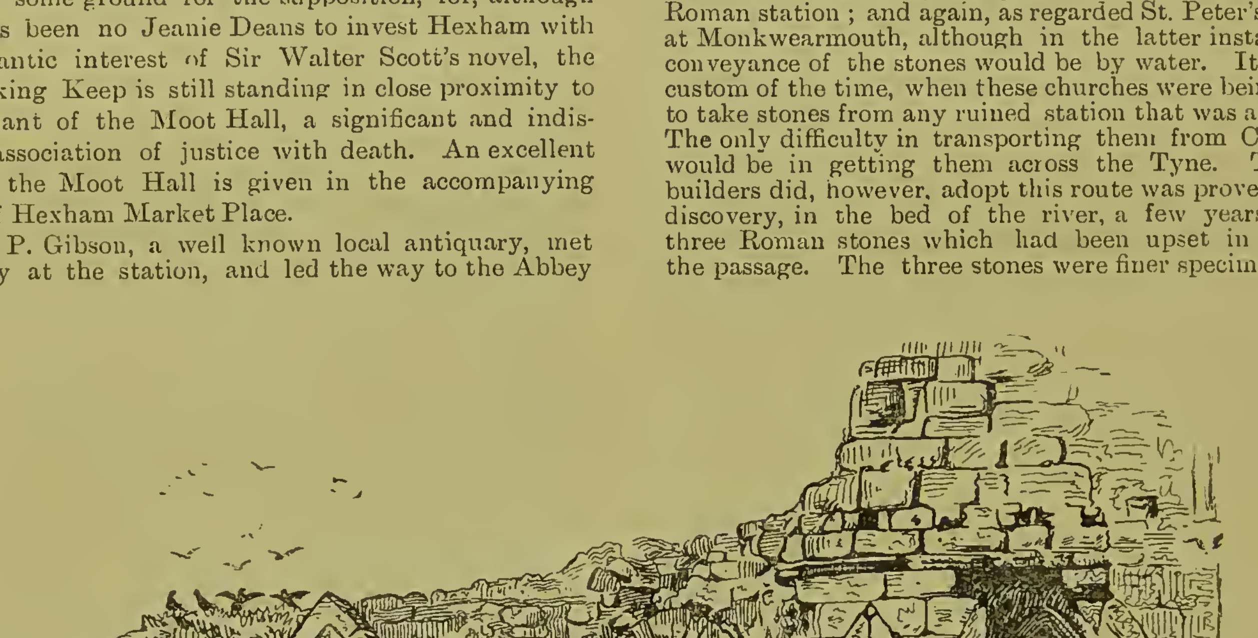
It was not, however, solely to observe what the Tyne Commissioners have done that the British Association members were furnished with opportunity. They saw a river wider, deeper, swifter than did those who went down the river on the last visit. And if on its banks glass and wooden shipbuilding have almost died out, greater industries have been planted. The marine engine works are now of vast extent; the development of shipbuilding provoked many exclamations of surprise even from one or two Irish members fresh from the notable yards of Belfast; and probably every one of the passengers on the J. C. Stevenson, from Sir John Lubbock to the less thoughtful youth, must have been impressed with the picture of the silent highway, banked with industries, wharves, and warehouses, and with the red-tiled terraces that gave animation to the picture, and that now and then furnished cheering crowds.

After the inspection of the manufacture of the concrete blocks, the visitors passed in groups to Tynemouth Priory, and were shown over a portion of what Gibson appropriately called the "time-worn remains of a once ecclesiastical structure, the famous Priory Church," a "reverend edifice long hallowed." And from it, after that refreshment which cannot be neglected, the return was made by train to Newcastle.

HEXHAM.

The British Association visitors who travelled to Hexham by special train on Saturday afternoon were fortunate in having the services of gentlemen highly qualified to explain the rich historic associations and to point out the architectural and picturesque features of the "Heart of All England." Antiquaries and historians are by no means decided as to the origin of this name, while the inhabitants themselves are disposed to resent the roguish suggestion that the old town, having formerly been a haunt of thieves, bears the same relation to England as that which the Tolbooth of Edinburgh bore to Midlothian. There is, however, some ground for the supposition, for, although there has been no Jeanie Deans to invest Hexham with the romantic interest of Sir Walter Scott's novel, the grim looking Keep is still standing in close proximity to the remnant of the Moot Hall, a significant and indisputable association of justice with death. An excellent view of the Moot Hall is given in the accompanying sketch of Hexham Market Place.

Mr. J. P. Gibson, a well known local antiquary, met the party at the station, and led the way to the Abbey Church, where he introduced the visitors to Mr. C. C. Hodges, of Sele House, the author of a beautifully illustrated work on the venerable edifice. After a cursory glance at the Abbey, which is described as "a very text-book of Early English church architecture," Mr. Hodges took up a position in the choir for the purpose of giving a preliminary sketch of the ecclesiastical and general history of Hexham. It was with some degree of interest that the visitors took their seats, when Mr. Hodges explained that the part of the church in which they were assembled was once used exclusively by the monastic body. This was the first time, he said, that the British Association had visited Hexham, and the first time that he had had the pleasure of speaking to a scientific audience on an antiquarian subject. The historical interest of Hexham exceeded, in his opinion, that of any other town in Northumberland —even that of Newcastle. Occupying an exceedingly picturesque position, and being well sheltered from the violence of storms, and also to a certain extent being naturally defended from the incursions of enemies, the site of the town was early chosen for occupation by man. Hexham, indeed, was a place occupied by the early inhabitants of this island long before we had any historical recollections or records. That was proved by the discovery of ancient burials and other evidence of a similar character, but there was no actual written record until the time of the Venerable Bede. There were in Hexham a very large number of stones worked by the Romans, and on that ground the town had been supposed to be the site of a Roman station. That supposition, Mr. Hodges declared, was entirely fallacious. The Roman stones must have been brought from Corbridge, the ancient Corstopitum. We had an example of this practice in the case of Alwinton on the Coquet, a church in a moorland district, nearly eight miles from the nearest Roman station; and again, as regarded St. Peter's Church at Monkwearmouth, although in the latter instance the conveyance of the stones would be by water. It was the custom of the time, when these churches were being built, to take stones from any ruined station that was available. The only difficulty in transporting them from Corbridge would be in getting them across the Tyne. That the builders did, however, adopt this route was proved by the discovery, in the bed of the river, a few years ago, of three Roman stones which had been upset in making the passage. The three stones were finer specimens than



Chapter House, Hexham Abbey.

HEXHAM MARKET PLACE.

those at the Black Gate, Newcastle, one being an altar of very large proportions indeed. Indications around the site of Corstopitum justified the belief that it was one of the largest Roman camps in the country. It was, therefore, unlikely that Hexham would be a place of any importance in that period, and, there being no Roman road that passes through the town, we might safely conclude, said Mr. Hodges, that it was not a Roman station. Having disposed of this theory, the speaker referred to the detailed information given in the pages of Prior Richard, and also in the writings of the Venerable Bede, as to the foundation of the church, proving its Saxon origin. He dwelt upon Oswald's victory at Heavenfield, the memorable debate between St. Wilfred and Coleman at Whitby, and the religious influence of the former upon Northumberland, culminating as it did in the grant of Hexhamshire from Queen Etheldreda, the founding of the monastery at Hexham, and the building of the Church of St. Andrew. Eventually Hexham was made a bishopric, and twelve bishops sat in succession in the chair; but soon it descended to the level of a parish church, and the Saxon edifice had now entirely disappeared with the exception of the crypt underground and a few isolated fragments. The Danes had had their share in the work of destruction In the time of Henry I., however, the colonisation of Hexham with monks from York resulted in the founding of the Priory of the Austin Canons, and the commencement of the present building; but what with the predatory visits of the Scots, and the chronic impecuniosity of the monks themselves, an architect's designs appeared never to have been carried out completely. Then came the disastrous time of the "Pilgrimage of Grace," when the brethren, headed by the Master of Ovingham, resisted the Commissioners of Henry VIII., who came to dissolve the monastery; and, as a result, on the suppression of the rebellion, many ecclesiastics were "tyed uppe," the last Prior of Hexham, believed to be Augustine Webster, being hanged at Tyburn. [We present our readers with a sketch of the Chapter House and also with a drawing of the ancient gateway, as spared by the spoiler.] As to the town of Hexham itself, said Mr. Hodges, in concluding his interesting address, it was probably as large in 1700 as it was in 1400, and it is very little larger now than it was a hundred years ago.

The party was now divided into three companies for the exploration of the Abbey and its precincts, and a lively interest was shown in the archæological mysteries of the Saxon crypt, which, situated close to the south-west pier of the tower, is entered by means of a trap door and ladder. While Mr. Hodges and Mr. Gibson conducted their respective squads through the transcepts, delighting the visitors with their profound antiquarian knowledge and entertaining comments, the first batch, including a witty barrister and several others in whom the sense of humour was fully developed, descended into the "dim religious light" of the crypt under the care of the parish clerk, Mr. Robson. This individual is an enthusiast of a most original character, and as the prototype of "Old Mortality." would have suited Sir Walter Scott even been than Robert Patterson. His special hobby is to dig for relics beneath the foundations of the Abbey. He chooses the dead of night for his operations, and alone in the gloomy aisles, working by the light of candles, he digs his way down eleven feet below the surface till he reaches the level of the transepts, where he hopes to find evidence of the past. In the morning there is no trace of his trenches, and he never reveals their existence until he discovers something of historic value that will justify his doings in the eyes of the churchwardens. He is wrapt up in the history and traditions of the Abbey, and he expressed the pious wish on Saturday that if, in the course of his operations, the Abbey fell, he might be buried beneath the ruins. "But do you never tell your wife?" asked one of the ladies present. "Oh, yes," was the reply, "and I often get it hot. She says that I smell of death!" It was this antiquary of antiquaries, then, who acted as conductor. Stumbling along a narrow passage after descending the ladder—half-a-dozen of the company bearing candles—a representative gathering of the British Association found themselves in the crypt which, in the early days of Christianity in our island, contained the sacred relics of the Church of St. Andrew. The visitors, indeed, were treading in the footsteps of the worshippers who, according to their rule, looked upon the relics before passing into church. In his quaint style Mr. Robson explained the method adopted, showed the curious lamp niches—mere hollow cups for holding tallow and a wick — and pointed out the curiously worked stones which had been brought from Corstopitum. These stones our conductor had, by long and patient labour, stripped of their covering of Saxon cement. One, for instance, displayed a tree in full foliage, with birds sitting upon the branches. But the most singular discovery of all was that of the tablet from which the name Publius Septimus (Geta) had been chipped out. This recalls that tragedy of Roman history when Geta was basely murdered, in the presence of his mother, by the minions of his brother Caracalla. Wishing to destroy all memory of the crime which left him sole ruler, Caracalla gave orders that Geta's name and titles should be erased from all monuments throughout the empire. It was in the Saxon crypt of Hexham Abbey on Saturday afternoon that ocular demonstration of the fact was supplied to the British Association. When told of the discovery, said Mr. Robson, the late Dean Stanley would not believe it though he read it in ten thousand volumes, but two months afterwards, having thoroughly satisfied himself as to its genuineness, he delivered a lecture on the subject. Back through the passages, the roofs of which it was observed were smoked with the initials of visitors, the party reached the ladder, and emerged into the light of day to make room for equally eager explorers. Mr. Robson then led the way to the foot of the dormitory steps, down which, he remarked, the monks formerly came chanting the *Te Deum* and the *Jubilate*. Here he pointed out a finely-carved tombstone which he discovered on September 21, 1881, while making an excavation under the floor of the slype or porch, with a view to finding a crypt there. The carving represents a Roman soldier riding rough-shod over a fallen Briton, and bears the inscription (translated)—"To the gods the Shades. Flavinus a, soldier of the cavary regiment of Petriana, standard-bearer of the troop of Candidus, being 25 years of age, and having served 7 years in the army, is here laid." The carving was originally covered with Saxon cement, which Mr. Robson carefully removed. Mr. Robson, too, has a very ingenious method of restoring panel paintings, one of which, he avers, bears a strong resemblance to Lord Beaconsfield, and, as the barrister remarked, might probably be that of his ancestor.

Much interest was also expressed in a curious shrine representing Satan taking possession of the seat of a pilgrim who had loitered on the way.

Space, however, would fail to tell of the numerous other objects of interest, such as the Frithstool, or Sanctuary Chair, pointed out by the three courteous and obliging guides. On being re-united, Mr. Hodges conducted the party to the Moot Hall, the Manor House, the old Grammar School, and the Sele, where, after being heartily thanked for his kindness, he transferred the visitors to the genial care of Mr. Gibson. At six o'clock tea was served in the Corn Exchange, and before rising a hearty vote of thanks was passed to the conductors of the party, to which Mr. Gibson responded, remarking that it had been a great pleasure to have members of the British Association as visitors to Hexham, which of course the inhabitants regarded as being the chief place of historic interest in Northumberland.

Amongst those who journeyed from Newcastle were:—Dr. J. T. Dunn and Mrs. Dunn, Professor H. Lloyd Snape, Miss Lily Telford, Mr. Fred Gleadow, Mr. Chas. Thompson, Mr. Alexander Tate and Miss Tate, Mr. Arthur Briggs and Miss Briggs, Rawden; Mrs. and the Misses Pengelly, Torquay; Mr. W. S. Backhouse, Darlington; the Misses Williams, Clifton; Miss Catherine Ray, Hampstead; Miss Helen G. Scholefield, Newcastle; Miss Beth Finlay, St. Leanard's-on-Sea; Miss Clara Bennett, Mr. J. E. Noel, Mr. G. R. Dunell, Miss Lucy Brookes, Miss Clara M. Dale, Mr. W. M. Beaufort, Mr. Alfred C. Pass, Mr. Alfred E. Hudd, F.S.A., the Misses Whidborne, Mr. Archer Bowler, Mr. G. S. Bowler, Dr. C. R. Wright and Mrs. Wright, and Mr. Robert Thompson. We must not omit to mention that Canon Barker, of Hexham, took a kindly interest in the proceedings. The party left by special train at 7·30, after a hearty handshake with Mr. Gibson, who had contributed so greatly to the pleasure of the day.

MORPETH AND MITFORD.

Shortly after one o'clock the Central Station was beseiged by visitors of all sorts and sizes. Ladies and gentlemen were rushing to and fro, interrogating the railway officials, and in all manner of other ways endeavouring to find the platform whence the particular excursion of the British Association which they intended accompanying would start. It was a busy scene all round. There was a large demand for carriages on the North train by the party bound for Morpeth and Mitford, and also the party bound for Wallington Hall. At twenty-five minutes past one o'clock a relief train was despatched North, followed ten minutes later by the usual train, which contained the British Association excursion parties.

There was no incident worth recording here on the journey up, except, perhaps, that it was a slow train, and arrived at Morpeth a few minutes behind time. After the train had discharged its cargo of excursionists—both parties—the station presented a lively appearance. All had a sort of picnic air about them, and a glance at their faces, manner, and dress told at once that they were excursionists. Mr. Frank Marshall and Mr. C. J. Richardson got the Morpeth and Mitford party together, and, leaving the Wallington Hall contingent on the platform to wait for a train to convey them to Scots Gap, they were conducted into the old town. Morpeth is chiefly attractive for its splendid scenery and beautiful situation. It is a very old borough, and in 1552 obtained a grant of arms from Edward VI. with the appropriate motto: "*Inter sylvas et flumina habitans.*" The present lord of the manor is the Earl of Carlisle, to whom it came through the marriage of his ancestor, Lord William Howard, otherwise known as "Belted Will," with the heiress of the Dacres.

The party proceeded to view the remains of Morpeth Castle. This castle is generally understood to have been built at the close of the eleventh or at the beginning of the twelfth century, by Wm. de Merlay, one of the great families associated with the borough. In 1644 a party of 300 Scots, who had been left by the Parliamentarian General Lesley, as a garrison, sustained a siege of twenty days against an army of 2,700 under the Marquis of Montrose. The Gateway Tower, built in the fourteenth century by Wm. Baron Greystock, another of the great families connected with the borough, is occupied by the agent of the Earl of Carlisle, and the only other remains of the castle are a few fragments of the outer walls.

To the west of the castle is the parish church of St. Mary. It is an interesting building. The lower portion of the tower at the west end belongs to an earlier structure, and is transitional work; and the low pitched roof of the nave belongs to the perpendicular period. The most noticeable features in the chancel are the canopied sedilia, the fiscina, the low side window, the old stained glass in the east window, and the squints in the jambs of the chancel arch. There is a curious recess in the west wall of the lower room of the vestry, pierced at its head with a quatrefoil opening; as to the purpose for which this recess was used there is an amusing variety of opinion among antiquarians.

On proceeding to the town itself a large mound called the Ha' Hill was to be seen, and at the north end of the bridge crossing the Wansbeck are situated the remains of the chapel of All Saints. The next place of interest to the visitors was the Town Hall, and on the road thither a select party dropped in to the old and quaint hostelry the Queen's Head. Here it was that John Scott, afterwards Lord Eldon, and Bessie Surtees stayed on their return to Newcastle after their runaway marriage.

The Town Hall on the south side of the Market Place was designed by Sir John Vanburgh, and erected in 1714, and restored in 1870. The party was shown by the Mayor and Town Clerk the objects of interest here. The Corporation documents were brought out of the large oak chest and viewed by the visitors, and the Corporation plate was also exhibited. The excursionists showed a great amount of interest in the great mace of the town, dated 1604, which was presented to the Corporation by "Belted Will," and on which are engraved the arms of the Merlays, the Greystocks, and the Dacres. The branks also received a large amount of attention, and, it having been fixed upon the Mayor's head so that his Worship could not open his mouth, the funny man of the party—what would an excursion party be without the funny man?—called upon Dr. Clarkson for a speech. An adjournment was next made to an anteroom, where the Mayor had kindly provided refreshments in the shape of wine and cake for the visitors. This was most acceptable to the party, particularly the ladies, who already began to show signs of fatigue; and every one knows what a tiring game sight-seeing is. One lady sank into a chair exhausted, and exclaimed in low but sincere tones: "Well, they are sensible men in these parts." Mr. F. Marshall moved a vote of thanks to the Mayor, Dr. Clarkson, and the Town Clerk, Mr. Brumell, and his worship in responding said it was a pleasure for him to be there that day, and he would be glad to see all of them back again.

Mr. Marshall gathered his little army together again, and led them up Newgate Street to the Church of St. James the Great, built in 1844-6 from the designs of Benjamin Ferry, F.S.A. The church, approached by a beautiful avenue of lime trees, is in the modern style of Norman architecture. The interior is superbly decocrated and is lighted by several stained glass windows, representing Scriptural scenes; and in the apse is an elaborate fresco of the incarnation of the eternal word.

The party next proceeded westward up the river to Mitford. The air was delightful, and it was exceedingly pleasant to pursue the journey by the side of the Wansbeck up to Mitford. After going about a mile from Morpeth, they came upon the remains of Newminster Abbey, situated on a triangular shaped plateau, somewhat raised above the level of the river, and sheltered on three sides by the Abbey Banks. The abbey, called "The first daughter of the Holy Church of Fountains," was founded in 1139 by Randulph de Merlay, the lord of the manor, for a colony of monks for the newly-built house of the Cistercians, which he had casually visited, and the plan of its buildings was almost identical with that of the famous Yorkshire Abbey. The monastery was dissolved in 1535, and its valuable and extensive possessions were distributed amongst various persons. All that now remains of the abbey buildings is the small archway of the door of the church which stood on the north side of the conventual buildings.

The journey by the river Wansbeck was continued after examining the remains of the abbey. The scene is delightfully rich and varied, and Wm. Howitt once said that the valley from Morpeth to Mitford, about two miles in length, was one of the most lovely in England. Passing through the picturesque little village of Mitford, which was once a place of greater importance than Morpeth, they reached the parish church dedicated to St. Mary Magdalene, which is an ancient stone building in the Norman and early English styles. Lately, by the munificence of Col. J. P. Osbaldiston Mitford, the present representative of the Mitford family, it has been restored at a cost of £10,000. Colonel Mitford met the party at the church, and said he was glad to see them all. He explained the restoration of the building. The church is Early English, and stated to be one of the most perfect specimens in the Archdeaconry of Lindisfarne. Its old sedilia and aumbry still remain, and it contains the quaintly inscribed monument of Bertram Reveley, who died in 1622. On the south side are a very fine Norman priests' door and a small lancet-headed splayed low-side window. At the Restoration a very beautifully carved reredos, executed in Bruges, with painted side panels representing St. Aiden and St. Cuthbert was added. The fine Norman nave, which is all that remains of the original church built in the twelfth century probably by William Bertram, the second baron, has been subject to a great deal of renovation; the walls have been heightened to admit of celerestory windows, and a tower has been added. There is a pretty little chapel on the south side of the church called the Mitford Chapel. In the vestry opposite, which goes by the name of Pigdon Chapel, is preserved a curious old bell said to have been cast 700 years ago. In the new tower which replaced the turret is a fine peal of 8 saucer-shaped bells, rung by machinery and playing a number of tunes. While the party were at the church the bells played "The Church is one Foundation" admirably. All the main lights in the church have been filled with stained glass. Those in the chancel by Messrs Clayton and Bell; that in the west wall of the tower by Messrs. Mayer, of Munich; those in the Mitford Chapel by Wailes, of Newcastle. The communion plate consists of three pieces, a silver cup, inscribed on the edge "Mitford Parish, 1689," a flagon, inscribed M.P. 1701 and a pewter plate. The parish registers begin in 1652, from which time, with few exceptions, they are tolerably perfect.

The party were next taken over the ponderous ruins of Mitford Castle by the gallant colonel. The ruins are seated on a lofty knoll on the south side of the valley, just over the Wansbeck. The Castle was first referred to in 1217, in which year Alexander II. of Scotland laid siege to it. After a century of Border warfare it was dismantled by the Scots, and in 1327 is said to have been in ruins. There are still remains of the Keep, with the vaults beneath it, and the massive outer walls. The party were very much interested in a remnant of the old manor house, to the north of the castle, and near the church, consisting of a battlemented tower, with large mullioned windows. Over the arched entrance are the arms of Robert Mitford and Philadelphia Wharton, with the date 1637 above them. In the adjoining cottage, formerly the kitchen of the hall, a large and stately fire-place is preserved, and on the left-hand side of it a curious old dog-spit wheel or turnspit.

The party afterwards crossed the river by a suspension bridge, giving access to the large and stately mansion of Col. Mitford. The house stands in a finely wooded park. On arriving at the mansion, the ladies were shown into a preparatory room, where they could divest themselves of jackets, bonnets, &c. The gentlemen were shown straight into an outer room, where a nice tea was set out. The ladies stayed away a little longer, perhaps, than was necessary, which made the comic man rather restless, and he showed extraordinary anxiety to go in quest of them. However, they shortly after put in an appearance, much to the delight of the humorous one.

Amongst those present were Mr. Frank Marshall, Mr. C. J. Richardson, Dr. Kirkpatrick Pickard, and Miss Burnett, Newcastle; Messrs. W. Butterworth and Geo. Jackson, Manchester; Mr. and Mrs. E. Simpson and Mr. W. C. Simpson, Newcastle; Mr. R. Horn, Leybourn; Messrs. William White, Busby, Rapkin, Corcoran, Miss Lovell, Mrs. Wellington, Mr. Bros, London; Mr. Sidney Young, London; Mr. Pritchard, Miss Richardson, Miss Norton, Caemarthen; Mr. J. A. Dixon, Gateshead; and Councillors Harkus and Beattie, Newcastle. After despatching tea, Mr. Frank Marshall moved a vote of thanks to Colonel Mitford. (Cheers.) They were very deeply indebted to their host and hostess, not only for entertaining them that day, but for the thought in preserving the very interesting church and having regard to the relics they had seen. He thanked the host and hostess for their generous hospitality on behalf of the local secretaries of the British Association and on behalf of the visitors; and their thanks were also due to Mr. Holcroft, Mr. Bowmaker, who had assisted them in their journey along and so kindly described what they had seen. The vote of thanks was seconded, and carried with acclamation.

Colonel MITFORD said nothing could give himself and Mrs. Mitford more pleasure than to meet the company there that day. Throughout his life he had always taken a deep interest in Mitford, before and after he came into possession of it; and he always regretted to see the pitiable state that the church was in. When he was much younger than he was now, it used to give him a great deal of pain to see the church in the condition it was, and he registered a vow that if he ever had the power and means and opportunity he would make that church as it should be—fit to be seen. It had pleased the Almighty to permit him to carry these resolutions into execution, and he was glad he and his neighbours and those persons who had come to view the church had been entirely satisfied with the way in which it had been done. (Applause.) He was sorry the company could not have come a little earlier to Mitford, when there was broad daylight, and when they might have seen things to better advantage. He was sorry they had to go through the place in such a hurried way, but they bid them all welcome that day, and were extremely sorry they did not have more of the visitors' company. (Loud applause.)—Through the kindness of Col. and Mrs. Mitford, a large number of the party were driven to Morpeth Station, where they met the Wallington Hall excursionists, after having spent a most enjoyable day.

WALLINGTON.

One of the most pleasant and enjoyable of Saturday's half-day excursions was unquestionably that which took place to Wallington, the seat of Sir George Otto Trevelyan, M.P. The applications for participation in this section of the programme were considerably in excess of the limit which it had been found necessary to impose; and highly favoured were the fifty or sixty ladies and gentlemen to whom the good fortune was extended. The weather, which forms so important an element in outdoor gatherings, was, happily, in most accommodating mood, for although the sun refused to pour forth his warming rays, the cool and bracing atmosphere which prevailed throughout was highly conducive to the comfort of the excursionists. The party, who were under the general guidance of Mr. Robert Blair and Mr. John Philipson, J.P., left the Central Station by ordinary train at half-past one, special first class carriages being provided for the visitors to Wallington. Among the members of the company were :—Mr.

Evans, of the British Museum; Mr. Philip Hartog, London; Mr. John Geddes, Southport; Mr. W. H. Richardson, Jarrow; M. Edmond de Tournay, Brussels; Mr. Edward Watson, Gateshead; Mr. J. G. Watson, Newcastle; Mr. J. W. Taylor, architect, Newcastle; Mr. Yeoville Thomason, London; Mr. H. H. Howorth, M.P.; Mr. C. Neild, Manchester; Mr. Francis J. Clark, Somerset; Mr. John Bright Clark, Somerset: Ald. Green, Tynemouth; Mr. Joseph Jackson, Newcastle; Mr. Bateman Brown, J.P., Huntingdon; Mr. Joseph Fryers, Durham; Mr. Joseph M. Hayward, Durham; Mr. J. Studdert Redmayne, Oxford; Mr. J. Arthur Berry, Cambridge; Mr. Thomas Kingston, Windsor; Mr. J. C. Logan, M.A., Newcastle; Mr. J. C. Blackett, Thorpe Lea; Mr. W. D. Savage, J.P., Brighton; Mr. and Mrs. J. M. Knight, Wanstead, Essex; Mr. Robert M. Barrington, Co. Wicklow; Mr. W. Peebles, Dublin; Mr. J. G. Benson, Newcastle, and others.

Scots Gap, on the Rothbury branch of the North British railway, and the nearest station to the place of destination, was reached about three o'clock; and on alighting from the train the party found in waiting a number of brakes and other vehicles which conveyed them to Wallington, a distance of a little over two miles. During the short and lightsome drive there was passed the picturesque little village of Cambo, where the neat parish church and the comfortable-looking and well-kept houses of the workpeople connected with the estate, were prominent objects of observation.

On reaching the appointed rendezvous, the company were most courteously and cordially received by Sir George and Lady Trevelyan, whose genuinely frank and homely manner at once placed all who were present *en rapport* with the surroundings. In this respect, the ancient tradition as to the hospitable disposition of the family was well sustained, for, as the local song hath it—

> Harnham was headless, Bradford breadless,
> Shaftoe picked at the craw,
> Capheaton was a wee bonny place,
> But Wallington banged them a'.

In attention to their guests, the worthy host and hostess found helpful assistants in their sons; and the Rev. Mr. Fitch, vicar of Cambo, who formerly laboured at Gateshead, also rendered willing and useful service in a similar direction. Luncheon having been partaken of, the visitors speedily devoted themselves to an inspection of the mansion and of the numerous objects of art and vertu with which it abounds.

The germ of the house is what Leland, the antiquary, in his Itinerary, has called "a faire tower, the chief seat of the Fenwicks." For three hundred years or more the members of that family were constantly getting together a great estate in the neighbourhood, of which Wallington was the chief. The house is a very ancient one; indeed, its origin is quite unknown. Two wings were thrown out at a very early period—one facing the south and the other the west. When the estate was transferred from the Fenwicks to the Blacketts, in the reign of William III., Sir William Blackett pulled down the very old castle in the upper storeys, leaving what is now called the ground floor, around which earth was heaped, so that the lower storey of the old castle became what are termed the cellars of the modern house, and very curious and interesting these cellars are. There was one room 50 feet long by 20 feet broad, and there were considerable fragments of other rooms. These are the strong rooms on the ground floor, into which the horses and cattle used to be driven in times of danger. Then Sir William Fenwick built a perfectly square house, in the form in which it now exists, nearly facing the four points of the compass, what remained of the old castle being adapted to modern use. There were no passages, each room opening with the one adjoining, and there were four staircases—one for each storey—so that each room had two outer walls. Subsequently, other alterations were made, by which the rooms were connected in the modern manner both above and below by staircases. These changes were followed by another made by the late Sir Walter Trevelyan, who threw an iron and a glass roof over the open court in the middle of the building, and converted it into a beautiful central hall, which binds the whole house together. Into this stately apartment, which was transformed by the late Mr. John Dobson, of Newcastle, into a beautiful and unique picture gallery, the excursionists were ushered at an early stage of their sojourn. On the ground floor, two sides of the great central loggia are divided by arches into eight panels decorated with frescoes by William Bell Scott, the poet-painter, and formerly master of the School of Art in Newcastle, the subjects being illustrations of Northumbrian history in various periods and states of society. Some of the intervening panels were painted by the late Lady Trevelyan; while one, representing some ears of wheat and barley and corn flowers, bear the monogram of Mr. Ruskin. Higher up the spaces between the arches are filled in by most effective compositions from Border history; and there are also medallions containing portraits of celebrated Northumbrians, including those of the late Sir Walter and Sir Edward Charles Trevelyan. Another attraction is found in the shape of a fine group of sculpture symbolical of the civilsation of England. After surveying the many features of this noble hall, which in itself has made Wallington widely famous, the party inspected the other apartments, in each of which there was found much to arrest attention and to command admiration. Especially interesting proved the rich and varied collection of old china arranged in cases throughout the principal rooms, and in which is included the large punch-bowl, inscribed, "Let us drink success to Blackett and Fenwick"—a memento of the memorable Newcastle election of 1741. Many of the company met with much congenial to their tastes in the library and study, in both of which were to be seen several literary and other memorials of Lord Macaulay, who has found so fitting and appreciative a biographer in his nephew, the present proprietor of Wallington. By way of further variety, the visitors were conducted through the park, which is studded with stately trees, to the large and beautiful gardens, on the walls of which are ranged several statuettas by Chere. So the time passed pleasantly and profitably away until about six o'clock, when, returning to the hall, the company were served with tea and refreshments.

The hour of departure now approaching, Mr. EVANS, on behalf of his fellow-excursionists, briefly returned their sincere thanks for the hospitality which had been extended to them by Sir George and Lady Trevelyan, and expressed their appreciation of all that had been done to contribute to their enjoyment and entertainment—sentiments which, needless to say, were greeted with hearty applause.

Sir GEORGE TREVELYAN, M.P., in responding, said: Ladies and gentlemen, it has given me great pleasure to hear the kind words which have come from the lips of so good a friend and so valued a colleague on the Board of the British Museum as Mr. Evans. I am afraid I brought to that Board very little that could match with the special knowledge of Sir John Lubbock, Sir Henry Rawlinson, and Mr. Evans, but I did my best. You have had a great deal of speaking during the past few days, and I certainly shall not add in any way to that burden. This is, indeed, a very nice place to come to for a little quiet rest. It is always delightful to think that there is, at any rate, one corner of the world in which one gets away from English politics of later date than the rising of 1715. (Cheers.) When I come to Wallington, my politics always stop at Sir John Fenwick and "white Sorrel," which was bred in the fields opposite, and which threw the great Liberal and killed him. (Laughter.) Another great delight of my life in this district, as you must all have seen as you passed through it, lies in the extraordinary and solid prosperity of the whole countryside, not affecting one class or another, but, like the pyramid, increasing as you go downwards in the social scale. Whatever landlords and farmers may be here—and I am sure they have no reason to complain—we feel that the people of this district are as happy as the people in any part of the country. Any pleasure you may have had in seeing this beautiful country and the objects in this house, will be increased by feeling that they are not enjoyed at the expense of the mass of the population. (Hear, hear, and cheers.) I am extremely obliged to you for the ease with which you have allowed yourselves to be pleased, and for the warm appreciation you have shown of what little kindness we have been able to offer you. It has been offered in the spirit of the greatest friendliness; and my only regret is that, from the want of accommodation, which is only that of a private house, we could not give a little Northumbrian hospitality to more visitors to this famous country. (Loud applause.)

Amid the farewells of their generous host and hostess, the party then drove off to the station at Scots Gap; and soon afterwards, leaving by special train, all reached Newcastle in safety at nine o'clock, having borne away with them what promise to be agreeable and enduring impressions of their visit to Wallington.

SEATON DELAVAL AND THE COAST.

A party numbering about fifty left Newcastle by the 1·45 p.m. train from New Bridge Street for Seaton Delaval, in order to visit the fine old mansion of the Delaval family, and thence to proceed by Seaton Sluice and the coast to Tynemouth. Fortunately the weather proved all that could be desired for a coast excursion, and as the party had the advantage of excellent guidance, the conductors being Major Adamson and Mr. Horatio A. Adamson, nothing that was of interest was passed by unseen. Major Adamson acted as *cicerone* for the earlier portion of the journey, and Mr. Horatio Adamson fulfilled a similar function when the visitors reached Tynemouth. Owing to an unfortunate misunderstanding as to the station at which they would be required, the carriages in which the excursionists were to be conveyed to Delaval Hall were not in waiting when they alighted from the train; but this hitch caused only a very slight delay. Having left the avenue and entered the grounds, the visitors paused for a moment to admire the splendid mansion erected in 1707, and which, even in partial ruin, remains as a monument of the genius of Vanbrugh and of the position once occupied by the Delavals amongst the county families of Northumberland. The story of the fortunes of the family, and of the mingled extravagance, eccentricity, and public spirit which characterised its chief representatives during the last few generations before the extinction of the male line, interested many of the visitors; and general regret was also felt that fire should twice have wrought its destructive effect upon the mansion. After an inspection of the interior of the building and of the little Norman chapel, the members of the party proceeded to visit the curious little harbour of Seaton Sluice which, in its decay, possesses abundance of interest for the antiquarian—interest which has been heightened by the recent discoveries of papers relating to the Delaval family amongst the lumber of disused bottle works and offices. From the once busy harbour the party journeyed on by Whitley and Cullercoats to Tynemouth, noticing by the way all the features which make the road along the coast so picturesque and attractive. The atmosphere was singularly clear, and there was just sufficient breeze from the sea to make the drive thoroughly enjoyable. Tynemouth was reached about five o'clock, and here the party united with the larger one which had just completed a river excursion. The ruins of the Priory having been inspected, tea was partaken of at the Bath Hotel, and then the return journey was made to Newcastle, some of the excursionists, however, prolonging their stay at the seaside for an hour or two in order to enjoy it at leisure.

THE FORTH BRIDGE.

LECTURE BY MR. B. BAKER.

PRESENTATION TO PROFESSOR FLOWER.

On Saturday evening, in connexion with the visit to Newcastle of the British Association, a meeting was held in St. George's Drill Hall, Bath Road, for the double purpose of the presentation of an address to the president (Professor Flower) by the Newcastle, Gateshead, and District Trades Council, and of hearing a lecture entitled "The Forth Bridge," by Mr. Benj. Baker, M. Inst. C.E. The hall was crowded. The Mayor (Mr. T. Richardson) presided, and amongst those on the platform were Sir Fred. J. Bramwell, the Bishop of Newcastle, the Bishop of Carlisle, the Sheriff of Newcastle (Mr. W. Sutton), Mr. T. Burt, M.P., Mr. Charles Fenwick, M.P., Canon Lloyd, Canon Franklin, Captain Noble, &c.

PRESENTATION TO PROF. FLOWER.

The Mayor said: Ladies and gentlemen, our first business this evening is the presentation of an address from the Newcastle, Gateshead, and District Trades' Council to the president of the British Association, Prof. Flower. (Cheers.) I now call upon Mr. Girling, the president of the Trades' Association, to speak to this address. (Cheers.)

Mr. Girling intimated that it was the desire of the members of the Newcastle, Gateshead, and District Trades' Council, on behalf of those whom they represented, to offer to Prof. Flower and the members of the British Association a hearty welcome to Newcastle, a city the commercial enterprise of which the industrial population felt proud. (Cheers.) They considered it no mean city that could claim names like those of Stephenson and Armstrong, men who, by their industry and research, had revolutionised the trade and commerce of the world. They welcomed the British Association to the birthplace of the locomotive.

Mr. J. J. Harris (secretary) read the address, as follows:—

To Professor Flower, C.B., LL.D., F.R.S., F.R.C.S., F.L.S., F.G.S., President of the British Association, Newcastle-on-Tyne Meeting, 1889.—We, representatives of the various societies constituting the Newcastle-on-Tyne, Gateshead, and District Trades' Council, desire to offer you and the members of the British Association a hearty welcome to the city of Newcastle. We venture to think it a matter for congratulation that the council of the Association should have selected as president for the meeting this year, in a commercial city like Newcastle, devoted to the pursuits of practical science, a man so eminently connected as yourself with the advancement of pure science in its various parts, thus recognising, by their choice, the important bearing that the study of the two branches with regard to each other, has in the everyday affairs of life. We trust you may be long spared to continue your researches in those fields of science you have made so especially your own, and that in years to come your visit to our ancient town may be one of your pleasant memories.—(Signed) Ed. Girling (president); Jos. J. Harris (secretary).—14th September, 1889.

The address was then handed to Professor Flower.

Professor Flower, who was greeted with much cheering on rising to acknowledge the address, said: Mr. Girling and Gentlemen,—I beg to thank you, sir, and those societies which have joined together in presenting this address—I beg to thank you, in the name of the British Association for the Advancement of Science, for the kind way in which the address has been worded and the kind way in which it has been delivered. (Cheers.) It is most gratifying to us all to know—all of us who believe in the beneficent results upon human life conferred by the diffusion of science and knowledge, and as all members of this great association must do—that their work and that the object of their meeting is so highly appreciated by so wide a circle as that represented by the signatories to this address. (Cheers.) It is very gratifying to us to find such a recognition—where, perhaps, at first sight, we might hardly have expected it—of the advantages of pure or abstract science, apart from its practical application to the material welfare of mankind. You have recognised what is certainly known to those who have followed most closely the history of science—that it is not generally known or appreciated by the multitude, that nearly all the marvellous benefits which have been conferred on man by the application of scientific discovery or scientific knowledge have been the result of the discoveries of philosophers who are pursuing knowledge solely for its own sake—(cheers)—without any hope of reward, without any hope of its benefiting perhaps themselves or others, and very often amid the indifference, neglect, and even the scorn of their contemporaries. (Hear, hear.) The particular branch of science which I have the honour of representing is, at first sight, very little specially connected with the general welfare of man, and is looked upon by many as little more than idle speculation or curiosity. I well remember—it is certainly many years ago now—one who, more than any one else living in this country, has advanced that branch of science—Prof. Huxley (cheers)—in a lecture which he delivered at the Royal Institution, saying that the common idea of the naturalist was a wet, dirty man poking about the sea shore with a net in one hand and a bottle in the other—(laughter)—a perfectly innocent and harmless individual, but a very useless one. (Laughter.) Well, I may say that that description was made some thirty years ago, before Prof. Huxley himself had done so much to raise the character of the naturalist and natural history in this country, but still it holds good with many at the present time. But you must recollect that the researches of naturalists of that type—of men who have occupied themselves in merely observing the ways and habits and studying the structure of animals of a low type of organisation, have produced already marvellous results on the happiness of their fellow-men. Through researches of this kind we are now getting knowledge of the causes and of the prevention of disease, which, when further advanced, will, I have no doubt, lead to enormous saving of health and of life. Moreover, through the researches of such naturalists greater results still have been produced. They have produced effects on our mode of thinking on many subjects and our relations to each other the end of which we hardly see at present; and they have taught us one great lesson—one that I alluded to in the address I had the honour to give here the other night—that the great principle of nature, that progress in nature—in living nature: animal and plant nature, at all events—has been due, I think, in a great measure to the principle which Darwin most popularised, and which, if he did not first enunciate, at all events brought into the condition in which we now know it—that of the struggle for existence, and the survival of the fittest. Now, it is a law in nature that there should be a certain amount of individual differences or variations in different animals and plants, and that progress from the low to the highest forms of animals and plants has been due to the opportunity for those individuals who are a little superior in some respects to their fellows asserting that superiority by continuing to live and to propagate their descendents who inherit that superiority. Now, this law, fairly well established in nature, is, I believe, generally applicable to ourselves. And this is the message which research—pure and abstract biological research—has sent to help us on in some of the complex problems of human life. And the lesson is this: That there is always a certain amount of variability, that there is no such thing as equality in powers of work, in powers of endurance, or in powers of mind, and in doing great things in this world; that progress depends in giving opportunity for that superiority in the world having full swing. Supposing this law did not exist in the animal kingdom, instead of the world being filled with all the diversity and beauty which is now seen, everything would have been in the condition of slimy polypes at the bottom of the sea; and supposing such a law as this had not been allowed a certain amount of play, perhaps not so much as it ought to have had, we should have been in the condition of flint-chipping savages. Now, I leave it to you to apply to yourselves in your own social condition of social life the application of that law. I won't press it any further at present. It means that no attempt must be made to keep down the capacities of the superior to the level of the inferior. Every one who gets a little rise above his fellows helps on the progress of the world, and brings all the others on with him. (Cheers.) Now, having merely mentioned the application of abstract science from a quarter where you would little have expected it, I would conclude by once more thanking, in the name of the association, Mr. Girling and those who forwarded this address in the name of the society. It will give great pleasure to the association to hear what you have done, and that you have sypathised with their work. I assure you that the hopes and wishes expressed at the end of the address are, as far as possible most fully realised. (Cheers.) We have up to the present time most completely enjoyed our visit to Newcastle. It has done all of us a great deal of good. We have seen and inspected a beautiful part of the country which some of us had never seen before. We have seen the wonders that have been produced by the industry, perseverance, and genius of your fellow-citizens. (Cheers.) I wish to express especially our obligations to one of your fellow-citizens, whom I most deeply regret, and he himself regrets, that he is not here to-night.—I refer to Lord Armstrong—(cheers)—who unfortunately owing to the great labours of the last few days in hospitably welcoming and entertaining and making himself agreeable to all those who have visited your city, is temporarily, but only temporarily, I hope, indisposed, otherwise he would certainly have been with you to-night. To him and everyone else in Newcastle I should be glad if I could express the thanks of the association for the kindness of the welcome with which you have received us. (Loud cheers.)

MR. BAKER'S LECTURE.

The Mayor said: This interesting ceremony being over, we are now to listen to an address upon one of the most gigantic engineering operations of ancient or modern times. (Hear, hear.) It gives me unqualified pleasure to be here, because the intellectual feast which is this week spread before the inhabitants of Newcastle is to-night especially laid before those working men of this city who have not the opportunity on ordinary days of benefiting by it. This is especially, and I may say almost exclusively, a working man's meeting—(hear, hear)—and I have not the slightest doubt the audience will not fail to see the intimate connexion between science and their daily avocations. First, the man of science must conceive those great engineering ideas and principles upon which such a vast undertaking as this can be founded. Then the scientist commits to the skill of the workman the development of these ideas and to embody them in actual structures, so that brain and muscle, the highest intellectual thought and skilled workmanship are inseparable with all our scientific and engineering undertakings. (Cheers.) Upon the intimate and inseparable association of brain and muscle the complex system of society and all our modern civilisation are built up. The brain cannot say to the hand "We have no need of thee"; nor can the hand say to the brain "We have no need of thee." But by the cordial working together of the two the world is destined to see greater transformations than it has ever witnessed in the past. (Cheers.) I have now great pleasure in calling upon Mr. Baker to address you upon this Forth Bridge, of which he is the actual engineer. (Loud cheers.)

Mr. Baker, who was received with cheers. in the course of his lecture, which was illustrated by diagrams, said:—In the present age one of the penalties of being associated with a matter of public interest, be it a great crime or a great bridge, is that one is expected not only to endure all the worries and work belonging to the thing itself, but also to write about it, and to worry the public about it by giving lectures, such as I am about to give to-night. I will endeavour, however, to bore you as little as possible by long statements, and shall rely chiefly upon the photographs shown on this screen for giving you an idea of the design and construction of the great Forth Bridge. This will be to your advantage and to my own also, for I will frankly confess to you that, after seven years' work, I am pretty well tired of the subject, and should not from choice select the Forth Bridge as the topic of an hour's talk. Indeed, it was only from the fact that this was to be a workman's lecture that I agreed to give it to-night, in the middle of my short holiday.

TRIBUTE TO THE WORKMEN.

The Forth Bridge is essentially a workmen's bridge, and whenever I have had occasion to speak in public on the subject I have always endeavoured to do justice to the workmen, to whose individual and collective pluck and ingenuity it is due, as much as to the labours of engineers and contractors. As you will see when the photographs appear on the screen, this Forth Bridge involves so many novelties and difficulties in its construction that at the hundreds of points where work has been carried on, each independent group of men had to use their own brains and to originate expedients to overcome unlooked for difficulties on the spur of the moment, without waiting for instructions from the engineers or leading foreman in charge of the works. By this means only could the erection of the steel work be pressed on quickly and accidents be avoided. You can readily understand that the scheme of erecting some 50,000 tons of steel, between 300 and 400 ft. high above the sea, would depend very much upon who was going to do it. If a lot of nervous old ladies, for example, were alone available for this job, you have to provide them with staircases and handrails, and probably blinkers, like horses wear, to prevent them getting dizzy or shying at the great height. If, on the other hand, you could get an army of acrobats, you might introduce trapezes as a quick way of getting about aloft. Well, in our preliminary scheme for erection, we underestimated the capabilities of our men, which far more nearly approximated those of the army of acrobats than the lot of old ladies referred to. It is only one of the things for which, as I have said, we are indebted to our men. It is not necessary to tell Newcastle men much about the situation of the Forth Bridge now, and why it had to be built, because they see the flying expresses from London to the north pass daily, and they know of the keen competition that exists between the east coast and west coast routes. The Forth at Edinburgh, one mile to five miles wide, blocks the way on the east coast line of railway, and traffic has either to be taken across in ferry boats or to be diverted many miles round. The Forth Bridge will make the line of railway continuous. It has been long delayed on account of the great width and depth of the Forth.

THE HIGH LEVEL BRIDGE, NEWCASTLE.

Just 39 years ago the High Level Bridge in this city and the Border Bridge across the Tweed were opened by her Majesty, the Mayors of Newcastle and Gateshead ordering all factory fires to be extinguished on the occasion, so that the atmosphere might be free of smoke and Newcastle bridge be seen to the greatest advantage. The Forth Bridge is now being built for exactly the same reason that the High Level and Border Bridges were built 39 years ago, namely, to get an uninterrupted line of railway on the east coast of Great Britain. In the same year that the High Level was opened the ferry boat Leviathan, to carry the train across the Forth, commenced running. The Forth Bridge, as I have explained, supersedes these boats. It will serve to mark the progress in bridge building to show on the screen the comparative diagrams of the 1850 and the 1889 bridges. The former may appear insignificant now, but it was not so regarded at the time. Thus, I read in the *Spectator*, August 31, 1850, that "the Newcastle High Level Bridge has often been described, but few descriptions can convey the sensations of those who pass over it for the first time. The sudden view of ships' masts under the feet and the pigmy appearance of men and horses, as they move along the quaint old bridge lower down, give the passenger some idea of the dizzy height to which he is raised." You will be able to judge for yourselves from a diagram whether if that was true of the High Level Bridge when written, people's nerves must not have improved during the past 40 years to enable them to walk about the higher portions of the Forth Bridge in the way many of our leading visitors do.

THE EIFFEL TOWER.

On the same diagram is shown the much talked of Eiffel Tower, laid horizontally for comparison. You will see it is very much the equivalent of one-half of one of the spans of the Forth Bridge placed vertically. I leave it for you to judge whether it would be easier to build vertically or horizontally, or whether our French friends are justified in saying that such a bold undertaking as the Eiffel Tower could never have been conceived of by Englishmen. It is a graceful and thoroughly creditable work, but not so difficult, especially as regards the workmen engaged, as the Forth Bridge.

COMPARISON BETWEEN THE FORTH AND OTHER BRIDGES.

It is not easy to realise how vast is the difference in scale between a 1,700 feet bridge and all other railway bridges hitherto constructed. The largest bridge in this country—the Britannia tubular bridge across the Menai Straits—has a span of 465 feet. Therefore, the Forth Bridge spans are 3⅔ times as great. The arithmetical comparison will probably not help you much in itself, but I may assist your imagination by mentioning that a medium-sized horse is just about 3⅔ times the size of a medium-sized dog. The height of the steel work is also exceptionally great, being equal to the golden cross at St, Paul's, but this may be best shown by a diagram of the comparative heights of the different buildings.

PRINCIPLE OF DESIGN.

"Cantilever" is a 200 year old term for a bracket, and the Forth Bridge spans are made up of two brackets and a connecting girder. Imagine two men trying to shake hands across a stream a little too wide for their hands to meet. One man extends his walking stick and the other one grasps it, and so bridge the stream. There we have the two arms or brackets and a connecting girder. In the Forth Bridge the arms are connected by great struts, as in a living model which I showed at the Royal Institution a couple of years ago, where raking struts extended from the men's wrists to the points of support. The principle of bracket and girder construction is as old as the hills, for it lends itself particularly to timber construction, which we know in primitive times preceded masonry. Perhaps one of the most interesting of comparatively modern works of the kind is a bridge in Thibet, constructed about 230 years ago, and illustrated by diagram.

THE CANTILEVER SYSTEM OF CONSTRUCTION.

The adaptability of the cantilever system of construction for railway bridge spans became obvious to ourselves, and no doubt to others, soon after the invention of Bessemer made cheap steel a possibility. In 1865 we designed a steel cantilever bridge of 1,000ft. span for a proposed viaduct across the Severn, near the sight of the present tunnel; but it was not until 1881 that the Forth Bridge designs were published in the English and American technical journals. These designs naturally attracted much attention, and with characteristic promptness American engineers realised the advantages of the system, and designed and built the following year a steel cantilever railway bridge on the Canadian Pacific Railway, and he since followed on with more than half a dozen others of the same type of construction. One of the chief advantages of the cantilever system is facility and safety of erection, as such bridges can be erected by commencing at the piers and adding successive bays of the cantilever right and left until the whole is completed. There is thus no moment of insecurity, when the safety of the whole structure is dependent upon the integrity of some temporary staging springing from the bed of the river, even if shallow enough to admit of staging. At first glance, some people might think that a cantilever or bracket was not adapted to carry great weights or for long spans, but the reverse is the truth. In long spans the dead weight of the structure itself is the most important element, and since, as every mechanic knows, a bracket requires to be the strongest at the root, and lightened out towards the point, it follows that this main weight of the cantilever lies towards the support, and acts at a relatively small leverage. These cantilevers or brackets of the Forth Bridge are enormously strong. Many here are practically familiar with our enormous and ponderous modern ironclads, and will appreciate the strength of the bindage, when I say that half a dozen ironclads might be hung from the cantilevers.

COMMENCEMENT OF THE WORKS.

In 1883 a commencement was made with the works of the Forth Bridge on the present design. Simultaneously with the erection of shops and machinery for the manufacture of the superstructure a start was made with the pier-work. Each main pier consists of a group of four cylindrical masonry piers about 70 feet diameter, founded on rock or hard boulder clay at depths ranging up to 20 feet below high water. Six of the cylindrical piers were put in place by what is known as the compressed air system, that is to say, the piers were floated into position by building them hollow in the first instance and fitting them solid with masonry subsequently; the whole being enclosed in a bottom placed about seven feet above the external cylindrical skin, so that a huge diving bell 70 feet in diameter and seven feet high constituted the bottom of each pier. When in position the water was driven out of the chambers by forcing in compressed air, and men then entered through air locks and carried on the excavation 90 feet below the waves of the Forth as easily as on dry land; and the men suffered but little inconvenience beyond the usual pain in the joints which results from too long a stay in compressed air.

DESCRIPTION OF ONE OF THE PIERS.

I must content myself with describing briefly one of the twelve piers, which all differed somewhat in detail, and I will select one of the Inchgarvie piers pointed on a sloping fissured rock bottom, at a depth of 72 feet below sea-level to a very exposed estuary. The method adopted was as follows :—A huge wrought-iron bucket or caisson, as it is technically called, 70 feet in diameter and about 50 to 60 feet high, was built on launching ways like a ship. The bottom of the caisson was set up 7 feet above the cutting edge, and so constituted a chamber 70 feet diameter and 7 feet high, capable of being pumped full of compressed air, so that the men could work in it below the water as in a diving bell. The iron work weighed about 500 tons, and when towed out to position the added concrete and brickwork brought the total weight up to 2,700 tons. Additional concrete was then filled in, and when the weight reached 3,300 tons the caisson grounded in the sea bottom where a bed had been prepared for it with sand banks, the workmen entered through air-locks, and the rock excavation proceeded in this electrically-lighted chamber as safely as on dry land. The air pressure in the working chamber at times was as high as 35lb per square inch. We say the barometer is high at 31 inches, but in the working chamber it often stands 72 inches. When Coxwell made his high ascent the barometer fell to 7½ inches, or about one-tenth of the preceding height, which illustrates how marvellously the human mechanism is adapted to sustain wide variations of atmospheric pressure.

MANUFACTURE OF THE SUPERSTRUCTURE.

The superstructure of the Forth Bridge has required the manufacture on the spot of about 50,000 tons of steel girders and other work. As a rule the compression members consist of tubes, and the tension members of lattice girders. This arrangement, as was anticipated, is, from an architectural point of view, most effective, all columns and struts show up in strong, dark lines, whilst the ties look like delicate tracery. In making the tubes, the plates were beat hot, the edges planed, and the plates built up temporarily into long tubes, to be drilled by traversing machines through the whole thickness of plates. In practice, I may mention that our steel plates having an average tensile strength of 34 tons per square inch, drill more readily than iron plates of 22 tons. We have at times turned out as much as 1,800 tons of steel work per month at the Forth Bridge works. In no single instance have we had failure or even cause for anxiety out of the hundreds of thousands of steel plates, bars, and rivets which go to make up the superstructure of the Forth Bridge.

MODE OF BUILDING THE BRIDGE.

In ordinary cases bridges are built by means of scaffolding, but owing to the great depth of water and other considerations, this would obviously be impracticable in the case of the Forth Bridge. The method determined upon was to first build the great steel towers 370 feet high, and then to add successive bays of the cantilevers, right and left, until the whole was complete. The central connecting girder is being similarly erected in two halves, temporarily connected with the projecting ends of the cantilevers. This system offers great advantages as regards safety during erection, for there is no critical time, every part being securely bolted up as the work goes on. We have had ample evidence of this, for at no time have we suffered any danger from storms, and a few weeks ago during a very heavy gale the maximum movement, even in the unrivetted part of the work, was under half an inch.

RESULTS OF EXPERIENCE.

The great towers were erected with the aid of lifting-platforms and cranes, raised gradually from ground level to the full height of 370 feet by four hydraulic rams, one in each main tube. As the platform was raised, all the work immediately above and below it was built, bolted, and rivetted. The first half bay of each cantilever was similarly erected. Our experience so far has been that whilst the work of erection has been somewhat slower and more costly than we anticipated, it has, on the other hand, been less difficult and subject to fewer contingencies. We thought at first that the crane men and erectors would require practically to be close together, but we have found out, or rather the men have found out for themselves, that cranes 370 feet up in the air can handle work at ground level, and that the long steel wire ropes hanging from the crane jibs, instead of being destructive of their usefulness, are often of great advantage, as plates and bars can be swung out pendulum fashion to a distance far beyond the reach of the jib itself. This result of experience, combined with the boldness of the men, enabled us to dispense with the use of lifting platforms for the outer bays of the cantilevers, and in lieu of this mode of erection to use steam cranes travelling on the top. With increased experience we have erected as much as 2,350 tons of steel work in a single month. The cantilevers have been completed in the manner described by overhead cranes, and the erection of the central girders on the same system is well advanced.

THE CENTRAL GIRDER.

Almost every engineering visitor to the works during past years has asked "How are you going to erect the central girder ?" I have never varied myself in opinion as to which would be the best way of doing the work. In a paper read before the British Association at Southampton in 1882, or seven years ago, I said : "The central girders will be erected on the overhanging system, temporary connexion being formed between the ends of the cantilevers and central girders. The closing lengths or key pieces at the centre of each 1,700 feet span will be put in on a cloudy day (or at night) when there is little variation of temperature, and the details will be so arranged that the key piece can be completed and the temporary connexions cut away in a few hours, so as to avoid any temporary inconvenience from changes of temperature."

HOW FAR ANTICIPATIONS HAVE BEEN REALISED.

That is a sufficiently concise description of the plan now in progress for erecting the central girders. Now that the work is approaching the putting in of the last rivet, it is, you will easily imagine, interesting to those concerned to look back and see how far anticipations of six or seven years ago have been realised. For myself, I cannot say that I approached the work with a light heart. All that I hoped for was that I might make the fewest mistakes, and all that I claim as my share in the Forth Bridge is that I have spared no pains to attain that end. If the bridge had to be built again it would be possible to save both time and money; but no one knows better than any present practical engineer that the engine of a new type, or the first of any new piece of mechanism, cannot be expected to be as perfect as the second or third. Our anticipations and estimates as regards the cost of the Forth Bridge and the time of completion have, I am sorry to say, not proved an exception to the usual rule as regards novel undertakings, for both cost and time have been somewhat exceeded.

OLD ESTIMATES AND PRESENT FACTS.

The weight of steel has been somewhat greater than our contract estimates, but, strange to say, identical with a theoretical estimate made by myself many years ago for an imaginary railway bridge of 1,700 feet span across an imaginary Forth. I refer to this merely as a somewhat remarkable case of "coming events casting their shadows before." Twenty years ago, when quite a youngster, I was asked by an American to write a series of articles for a technical journal on long span railway bridges. These articles were afterwards republished and translated into German and Dutch, &c., in book form, and on page 75 of the English edition of the book it will be found that for an imaginary 1,700 feet span bridge, I proposed 20 years ago a steel cantilever bridge practically identical with the Forth Bridge, and I estimated the weight of steel required for its construction at nine tons nine cwts. per foot (space). Now, if you multiply the length of the Forth Bridge by this nine ton nine cwts. you will get the actual weight of steel in the Forth Bridge as nearly as I can give it you now. My rough estimate of 20 years ago, based on theoretical consideration without the aid of drawings, turns out by pure chance to be considerably nearer the truth than the carefully estimated weights from critical drawings which took a staff of perhaps 20 engineers more than a couple of years to prepare. This is of course a pure fluke, but curious enough to deserve mention, not only on account of the coincidence of the estimates, but also because I should have been led by chance 20 years ago to consider the problem of a 1,700 feet span railway bridge when no such work was contemplated, and that I should ultimately have by chance to take an active share in carrying out such a bridge.

THE BEST TEST OF SUCCESS.

The best test of the success of an affair, however, is to see whether other people are inclined to follow your lead. In that respect we have nothing to complain of, for since the commencement of the Forth Bridge many important bridges have been successfully completed on the same plan, and the contractors in all cases have been well satisfied with the economy and speed of the operations, and the stability of the structure. The Forth Bridge at present heads the list of great bridges, but it may soon be displaced. Last year a charter was granted for a 2,800 feet span bridge at New York, and Mr. Lindenthal, the engineer, has asked me to assist him in this matter. Our enterprising idealists of the other side of the Channel will be satisfied with nothing less than a bridge from Calais to Dover; and a few days ago the great firms of Schneider, of Creusot, and Hirseut, the original contractor for the Suez Canal and early part of the Panama Canal, brought over to me their preliminary designs for discussion. As an engineering question, the works we have done in the way of large spans at the Forth, and deep foundations at Sydney, have placed beyond doubt the practibility of a Channel bridge, but of course the enormous cost precludes the question being one of other than scientific interest. There is undoubtedly a great future before bridge builders, in which I hope British engineers and British workmen will take an active part. (Loud cheers.)

A CROSS CHANNEL BRIDGE.

The lecturer proceeded to say that he had had an opportunity of seeing Messrs. Schneider's plans for a bridge to cross the Channel The total length was 24 miles. the number of piers 120, the width of openings 320 feet—1,640 feet in the clear, the headway for ships 180 feet, the greatest depth of water 180 feet, and the height from the foundation to the top of the steelwork 600 feet. He showed a photograph of the proposed structure, which Mr. Schneider had kindly sent him, from the large oil painting now exhibited at the Paris Exhibition. They would see that there was a similarity between it and the Forth Bridge. He had compared estimates with one of Mr. Schneider's engineers, and they were both of the opinion that only the trifling thing of a million tons of steel work would do the little job. (Hear, hear.) That was, of course, without the piers. Therefore they would see that already both the Eiffel Tower and the Forth Bridge had been eclipsed, at any rate on paper. (Loud cheers.)

Mr. J. C. LAIRD proposed a vote of thanks to Mr. Baker for his address.

The motion was seconded by Mr. J. J. HARRIS. He said that 8,000 tickets had been applied for for the meeting, but they were not able to issue more than 3,500.

Mr. CHARLES FENWICK, M.P., supported the motion.

Sir FREDERICK BRAMWELL also supported the vote. He hoped Mr. Baker, in his reply, would answer three questions:—(1), What was the percentage of weight in the bridge which was there to resist wind; (2), what was the percentage of weight in the bridge which was there to carry the train; (3), what was the percentage of weight in the bridge that was there to carry the bridge itself, assuming that they had a calm atmosphere? (Cheers.)

The vote having been carried,

In reply, Mr. BAKER said as there was to be a Government inspection shortly, he would not commit himself as to the precise figures in regard to the stress put upon the bridge by load and wind. But Sir F. Bramwell was quite right in asking him to tell him the remarkable fact that wind pressure was far more severe and troublesome to provide for than the sole purpose for which the bridge was designed—railway trains. The wind-pressure provided for had been put in round figures at 2,000 tons. The lateral strain was estimated to be equal to this weight, while they should never get more than two coal trains of 400 tons each on the bridge. (Cheers.)

A vote of thanks to the chairman ended the meeting.

THE FIFTH DAY'S PROCEEDINGS.

MONDAY, SEPTEMBER 16, 1889.

MEETINGS OF THE SECTIONS.

SECTION A.—MATHEMATICAL AND PHYSICAL SCIENCE.

COMMITTEE REPORTS.

The Committee on Differential Gravity had nothing to report, but asked for a further grant of £10.

The Committee for the Collection and Identification of Meteoric Dust reported as follows:—Several of the members of this committee have had informal meetings, and collections of dust have been received from several important stations in Oceanic Island. Others are expected soon, and it is believed a detailed report can be shown up before the next meeting of the association. No money grant is required.

The Committee on Solar Radiation reported as follows:—The actinometer devised by the late Professor Stewart for the continuous measurement of solar radiation, which was described in the report of the association for 1887, is now ready for the preliminary trials, the internal thermometer with a flat bulb of green glass having been made since the date of that report. The construction of this thermometer occasioned a good deal more trouble than had been anticipated. No attempt has at present been made to render the instrument self-registering, as it would obviously be unwise to incur the outlay which any construction for this purpose would involve, only the result of preliminary trials were such as to encourage a hope that the instrument might be really useful if rendered self-recording.

The reports, which were read by Mr. R. E. Baynes, the recorder of the section, were received.

THE BLACK-BULB THERMOMETER.

An instructive paper on the black-bulb thermometer in vacuo was read by Professor McLeod, F.R.S., and a short discussion followed.

MAGNETIC OBSERVATIONS.

The committee for the purpose of considering the best means of comparing and reducing magnetic observations reported:—The committee are able to report the establishment of regular magnetic observatories, where continuous photographic records of the magnetic elements are taken, at the United States Naval Observatory at Washington, and also at Los Angelos, in California. The instruments used are of the Kew pattern, with the same time-scale, and the scale-coefficients for horizontal and vertical force instruments at Washington are very nearly those recommended by the committee in their third report (1887), and which are in very near agreement with those at Vienna, St. Petersburg, and some other observatories.

The committee report, further, that the plan proposed by them in their third report for the comparison and reduction of magnetic observations, has been adopted at the United States Naval Observatory at Washington, which is now prepared to take part in the general scheme of co-operation proposed by the committee. The committee are more than ever of the opinion expressed in their third report, "that the establishment of regular magnetic observatories at the Cape of Good Hope and in South America would materially contribute to our knowledge of terrestrial magnetism." The committee consider that it would be desirable to publish annually in a collected form for certain selected days the errors of three magnetic elements, *i.e.*, declination, horizontal force, and vertical force, taken at the different English and colonial magnetic observatories, choosing for selection in 1888 the days for which the curves are published in the "Greenwich Observations."—The report was received.

ATMOSPHERIC ELECTRICITY.

Professor Leonhard Weber had prepared a paper on Atmospheric Electricity, but in his absence, an abstract from the paper was read by Mr. Baynes, who said the chief thing in Mr. Weber's report was the results of certain experiments made by flying kites and by sending up balloons to which wires attached by wires to a galvanometer whose other terminal was put to earth. The results were only given for twelve bright summer days on which there were no clouds, the results on those days on which clouds having brought in various perturbations, being reserved for discussion on a future occasion. The intensity of the currents were plotted, and it was found that the higher the kite went the more intense the current became. Up to 100 degrees the current was in a negative direction, this being due to — E of dust and smoke particles which was compensated at 100 metres in height.

After a few remarks from Sir Wm. Thomson and Professor Michie Smith, Professor Weber was thanked for his paper.

Sir W. Thomson communicated a paper on the "Electrification of Air by Combustion," by Messrs. Magnus Maclean and Makita Goto. This was a description of a large series of experiments on natural atmospheric electricity carried on under the instructions of Sir W. Thomson at the University of Glasgow. Their purpose was to find out a relation between the electrification of the air within a room and the potential of the air in its neighbourhood outside, and also the causes which produce a change of electrification of air within an enclosed space. An insulated water-dropper and a Thomson's quadrant electrometer were used in the usual manner, but the deflections were observed by a telescope instead of by lamp. It was found that an enclosed mass of air is electrified negatively by the burning of a paraffin lamp, of coal gas, of sulphur, of magnesium, and of several other substances; and, on the other hand, the burning charcoal electrified a room positively. An arrangement was also described by means of which the burning substance was joined metallically to one of the quadrants of the electrometer, and precautions being taken to guard against the effect of the surrounding air, it was found that the substances which electrified the air negatively became positively electrified themselves. Some burning charcoal was found to give a deflection equivalent to 3 volt in the negative direction, the other terminal of the electrometer being joined to the case of the instrument and to earth.

No discussion followed the paper.

Professor C. Michie Smith also read a paper entitled "Notes on Atmospheric Electricity and the use of Sir W. Thomson's Portable Electrometer." In the course of his remarks he said they had in Madras at this season of the year frequent magnificent displays of sheet lightnings, and he had often made electrometer observations from the top of his house while these displays were in progress. In some cases an evident effect was produced on the electrification of the air, but in general it was found that the electrification was normal. This pointed to the conclusion that so-called sheet lightning might be divided into two classes. There was the reflection of distant lightning seen on the clouds or on the sky, but there was also, and it could be easily distinguished from the former, a series of discharges going on between two neighbouring masses of cloud. These discharges often took the brush form. At other times, fine flashes might be seen lighting up the whole mass of the cloud, and at times a large series of discharges almost parallel and simultaneous pass between the two cloud banks. Such discharges taking place at a considerable distance did not sensibly affect the electrometer. On the other hand, when the sheet lightning was simply the reflection from distant flashes, the electrometer was usually strongly influenced. From his own experience of thirteen years of the portable electrometer, he found that the instrument must be very differently treated in damp tropical climates to what was necessary in this country. The observer must be content with much less complete insulation. In the first place, the pumice must be charged with a much larger quantity of acid—as much as it would absorb without showing a moist surface. This involved more frequent drying, and he found that about once a fortnight was long enough to leave it. The greatest difficulty, however, was in charging the instrument at all. It was almost hopeless to attempt it with the small electrophorus supplied with it, and even when an electrical machine of any kind was used the greatest care was required in drying the charging end. Recharging was necessary every three or four days. He mentioned these things as he found that the neglect of the precautions had caused many people to think that the use of the portable electrometer in India was impossible.

Sir W. Thomson said the paper was most interesting, and had given him great satisfaction.

Mr. Glaisher, who presided during the temporary absence of Captain Abney, said the paper contained some most important practical remarks on making Sir W. Thomson's portable electrometer a very valuable instrument.

The thanks of the section were then accorded to Prof. Smith.

LIGHTNING.

Mr. Baynes (for Professor Leonhard Weber) read a paper on "Photographs of Lightning," which said that two photographs of lightning flashes had been photographed with a camera held in the hand, and so oscillated that the axis of the lens traced out an elliptic cone; thus the image of point that was luminous for one-third of a second at least would be an ellipse. Flash No. 1 ran horizontally and was rose-coloured, and in the photograph it appeared as a broad luminous band, with sharply-defined parallel edges, which represented the serpentine path of the flash. The rays were bright compared with the neighbouring parts within the band, as they corresponded to the turning points of the camera's motion. Flash number two was also rose-coloured, but ran almost vertically instead of between two clouds, its lower end being the roof of a distant house. The duration of both flashes was about half a second, but the change of luminosity with time was very different.

Sir W. Thomson said the paper showed the ingenuity of making an easy thing difficult. Photographs by the ordinary method were admirable and gave very clear results. The method described gave results which were scarcely entitled to be called clear.

Professor Hodge agreed with Sir W. Thomson as to the confusion in the paper.

Professor Weber having been thanked,

Mr. A. W. Clayden read a paper on "Dark Flashes of Lightning."

The registrations of the sunshine recorder showed 970 hours of sunshine during the year, the smallest number of hours for any month being 8 for November, and the largest 250 in June, being nearly half the possible sunshine. The number of hours for the four years now observed beginning with 1885 were 680, 576, 898, and 970. The contrast of the sunshine of 1886 with that of 1888 is thus very striking. The amount of the rainfall for the year was 132·46 inches, the month of least rainfall, 3·76 inches, being June, and of greatest, 20·60 inches, being November. The number of days on which precipitation was nil, or less than the hundredth of an inch, was 118. The number of rainless days for the three last years have been 159, 128, and 118. From all the observations yet made, it is seen that a fall, equalling at least 1·00 a day, has occurred on an average of one day in nine. Atmospheric pressure was this year again above the annual average, the mean at sea-level being 29·889, or 0·055 higher. The lowest mean at the observatory, 25·035 inches, occurred in March, and the highest, 25·590 inches, in September; the difference being 0·555 inch. At sea-level at Fort William the extreme monthly means were 29·636 inches in November, and 30·132 in September; the difference being 0·496 inch.

DETERMINATION OF THE RAINFALL.

Mr. Baynes read an extract from a paper contributed by Professor Cleveland Abbe on the "Determination of the amount of Rainfall." In the paper a general resumé of the general results of investigations on this subject was given. The paper stated that the deficit in catch by a gauge due to the eddies of wind was shown to be proportional to the velocity of the wind and to the relative percentage of small and slowly falling drops. The paper also gave an examination of the results for many years at many places in the United States and Western Europe.

HYGROMETRY.

The following is an extract of a paper from Professor Piazzi Smith, on Hygrometry in the *Meteorological Journal*. After noting the superior value officially attached to determinations of the mean temperature by observations of self-registering thermometers, recording its maximum and minimum every twenty-four hours, the author inquires why the still more difficult problem of ascertaining the mean daily moisture of the atmosphere is thrown over to a different principle of observing, long since condemned for simple temperature. Believing that the want of good self-registering dry and wet-bulb thermometers for the purpose was the chief obstacle, and having alighted on some recent makes of Sixe's thermometers with several very recommendable qualities, he invested two out of four of them with the peculiar fittings for wet-bulb hygrometers, after having made a table of index corrections for them all, as compared with standard thermometers. But as soon as hygrometric observations began, the depression of the wet, below the dry, bulb always came out at only two-thirds of what a standard but non-registering Glaisher arrangement gave out, for the horizontal form of Sixe; and no more than half for a vertical form. These differences of hygrometric statement, though rather puzzling for a time, were traced up to the wet-bulbs of the Sixe's thermometers being in contact on one side with the scale-plate. For when that plate in the horizontal Sixe form was cut entirely away from the bulb, and a new vertical form of Sixe was made (per Mr. James Bryson, Edinburgh) with its long thin bulb wholly outside the rest of the instrument, the indications of all three varieties of wet-bulb hygrometers became practically the same; and hygrometry was relieved of the old drawback on its registrations of maximum and minimum quantities of moisture in every twenty-four hours.

UNDERGROUND TEMPERATURE.

The committee appointed for the purpose of investigating the rate of increase of underground temperature downwards in various localities of dry land and under water presented a long report, in which a series of results were given. The report was printed, and copies were circulated.

THE TEMPERATURE OF WATER.

The committee appointed to arrange an investigation of the seasonal variations of temperature in lakes, rivers, and estuaries in various parts of the United Kingdom, in co-operation with the local societies represented on the association, presented the following report:—No formal meeting of the committee has been held, but some of the members have occasionally met informally, and the whole committee has been consulted by letter on all the arrangements which have been made. It is inadvisable to attempt at present to summarise the results of observations made, as although more than a year's observations are available on some rivers, it is only a few months since the work has begun on others. At the end of another year it is expected that sufficient data will be found to justify a comprehensive report on the subject. Several members of the committee have taken much trouble in collecting observations. Dr. Sorby has been good enough to collect and discuss a great mass of temperature observations which he had made from his yacht Glimpse in the estuaries of the south-east of England during the summer months of five successive years. This will be published separately. Professor Fitzgerald took charge of the observations in Ireland, where he induced a number of observers to take up the work. Mr. Willis Bund had already inaugurated similar researches on the Severn. Rev. C. J. Steward and Mr. Isaac Roberts rendered important services in their districts. The committee have to thank Mr. John Gunn for his services in forwarding thermometers and observation books and corresponding with observers. The committee ask to be re-appointed, with the addition of the name of the Rev. Mr. Andson, and with a grant of £50.

TIDAL ESTUARIES.

Dr. H. C. **Sorby** read a paper on the Temperature of the Tidal Estuaries of the South-East of England, and was thanked by the section.

MISCELLANEOUS.

The Hon. R. Abercromby was announced to read a paper on the weather and climate of the Nitrate Desert of Tarapaca, but he was absent, and, not having sent in his paper, the section proceeded to the next item on the programme, which was an exhibition by Mr. T. J. Murday of an apparatus for reading indications of distant meteorological instruments. Professor Stroud intimated that Mr. Murday would exhibit his instrument in the Physical Laboratory any time after eleven o'clock this morning.

THE REGULAR RETURN OF STORMS.

A paper on "The Regular Return of Storms" was announced for reading by Mr. T. J. Murday. Professor **Stroud**, in the absence of Mr. Murday, said that that gentleman had no theory to advance with regard to the recurrence of storms, and was of opinion that certain storms occurred at certain definite intervals of time. He was of opinion that certain storms occurred after a lapse of 349 days, whilst others took place after a lapse of 363 days, and others again at longer intervals. He did not advance any theories, but gave these statements as the results of observations extending from 1880 to the present time, and predicted what would be the date of storms to come. Mr. Murday was going to advance his theory on some future date.

No discussion followed the announcement.

THE PERIODICITY OF MILD WINTERS.

Mr. R. E. W. Goodridge was to have read a report on "The Periodicity of Mild Winters," but this gentleman was also absent. Mr. Baynes announced that in a communication to the secretaries of the association, Mr. Goodridge had expressed himself in support of Mr. Shuter's deduction as to the eleven year period of mild winters. The announcement excited no comment.

JOINT SITTING WITH SECTION C.

This concluded the day's programme, and the section then received a visit from Section C, to hear a paper by Professors A. W. Rücker and T. E. Thorpe "On the Relation between the Geological Constitution and the Magnetic State of the United Kingdom." The following is a short abstract of the paper :—During the last five summers the authors have determined the magnetic elements at 200 stations, distributed over the whole of the United Kingdom, and have employed the results of their observations in a study of the disturbing magnetic forces in play in various districts. It was generally known that the magnet did not point due north, and that the declination or deviation from true geographical north is different in different parts of the world. At London it is about 18 deg. west, and is greater at stations which are either to the north or west of the metropolis. Thus, if all disturbing causes were removed, an observer travelling due west from London would find that the declination increased by about half a degree from each degree of longitude. In fact the rate of increase, though equal on the average to this amount, is irregular. Between London and Windsor it is considerably larger, and between Windsor and Reading smaller than the mean. The forces which produce these abnormal variations depend upon the geological character of the district. They may be called local or regional disturbing forces, according as they influence small or large areas. Two principal theories have been proposed to account for such phenomena. Many igneous rocks, and notably basalt, contain magnetic oxide of iron, and the deviations of the needle may be explained by the presence of such rocks, either visible upon the surface or concealed beneath it. The other explanation associates the deflexion of the needle with disturbances of the earth currents of electricity produced by irregularities in the geological constitution of the country, and especially with geological faults. In attempting to decide between them, the authors point out, first, that even igneous rocks which are very feebly magnetic, when tested in the laboratory, produce very considerable effects upon the magnet when in large masses. Thus the Malvern Hills, though composed of durite in which magnetic polarity can barely be detected, produce deviations of minutes of arc at a distance of a mile from their axis. Second, Mr. Preece, F.R.S., Chief of the Telegraph Engineering Department of the Post Office, most kindly caused measurements of the earth currents to be made in two districts, in which the authors had discovered large deviations of the magnet. In the neighbourhood of Melton Mowbray, it was found that the largest difference of potential magnetism per mile was about 40 times less than that which accompanied a similar deviation of the magnet at Greenwich during a magnetic storm. On the whole, then, the authors thought that the theory of the direct action of magnetic rocks agrees best with the observed facts, and they showed that the kingdom can be divided into a small number of magnetic districts in which the direction of the disturbing forces are evidently closely connected with the geological constitution.

SECTION B.—CHEMICAL SCIENCE.

SOLUTIONS.

The committee appointed to report on the Bibliography of Solutions presented their third report, from which considerable progress was evident in the work entrusted to them, a large number of volumes being collated with some 635 papers therein on the subject of solution. A second report from a further committee on the Proportions of Solutions was presented.

LIGHT AND THE HYDRACIDS.

Mr. **Richardson** next read the report of the Committee on the Action of Light on the Hydracids ; and to the value of this report testimony was borne by Professor Liveing, whilst Sir Lowthian Bell remarked that the object of the communication being read was to secure a grant from the British Association for the further prosecution of the research, and this, as president of the section, he would be glad to support.

OTHER REPORTS.

Further reports on the Silent Discharge of Oxygen and on the Bibliography of Spectroscopy, were presented—reports some of which were characterised by the president as entailing very dry work, and therefore entitled the more to the thanks of the section.

SELF-REGISTERING ACTINOMETER.

Dr. **Arthur Richardson** then read a paper on "A New Form of Self-Registering Actinometer," the form of construction and working of which were illustrated by specimen apparatus and by diagrams, the object aimed at being stated, in reply to a question, to measure the relative amount of different lights from day to day.

CHLORINE COMPOUNDS.

Professor H. B. **Dixon** followed with a paper "On the Explosion of a Mixture of Hydrogen, Chlorine, and Oxygen." A further paper was read by the same gentleman, on the "Action of Light on Dry Hydrogen and

Chlorine," and two or three experiments were given to the evident gratification of the audience.

ARTISTS' COLOURS.

Dr. A. P. Laurie next read a paper on "Artists' Colours." He said it was a rather fragmentary paper which might open out a wide field of research, and might suggest much. He had been inquiring as to the mixtures of oils and colours and the methods of manufacture, the colours used by the old masters, and the literature that showed the receipts, with the view of looking into the reasons for the fading of colours. Looking into old Italian literature, he found much that bore on the subject, though it was often of a more curious than practical nature. Often they were told to allow certain mixtures to settle whilst they said a paternoster. One point in relation to the old masters, however, that came out was the large amount of vegetable colours they used, many of which were not used by modern painters. Possibly the reason was that they "locked up" the colour in coats of varnish. He had himself prepared some madder lake, getting a very rich colour from it. The receipt for it was a short cut to the ordinary way of Turkey red. Again he had investigated, in some degree, the ordinary methods of manufacturing colours, and his researches showed the need that there was for looking closely into the method of that manufacture, before choosing colours for very important pictures. He illustrated this point with several samples of colours, showing the variation in different makes of the same colour. As to vermillion, for instance, he indicated the modern methods of manufacture, and added that in some specimens sulphide of potassium was discovered. In Prussian blue, he showed by example that it would never do to compare two samples made by such different methods as there were in use. As to oils, he pointed out that one of the most valuable oils used by the old masters was walnut oil. This was a field of research just begun, and, as it dealt largely with trade secrets, it was obvious that it could only be slowly pursued. Indeed, a good part of his time had been taken up in standing drinks to people connected with oil and colour works to obtain information. (Laughter.) Still, the points he had referred to were of importance to artists and to the buyers of pictures.

In thanking the author of the paper, the Chairman remarked that those who had to pay £2,000 for a picture would be well able to appreciate the hints as to the fading of the colours.

A SPECTROSCOPE WITHOUT A LENS.

Dr. A. Scott read a paper on the "Composition of Water by Volume"; and Dr. William Newton one on "The Substitution of Latent Heats in relation to the Combined Heats of the Elements." The final paper was read by Mr. P. Braham on a "Spectroscope without a Lens." It is as follows :—The instrument consists of a taper tube, with an adjustable slit, 2½ inches long, similar to a parallel rule, at one end, and a prism at the other. The length of the tube should allow the slit to be at the distance of distinct vision. Although the spectroscope is without a lens, the eye acts the part and produces the image on the retina, which is dispersed by the interposed prism. The comparison prisms or mirrors can be easily placed before the slit, and the instrument can be easily made by any one with ordinary constructive ability at a small cost, enabling those whose means are limited to experiment, verify facts, and penetrate the charmed circle of brass and glass, to the popularisation and advancement of science.

The meeting then adjourned, to allow time for

VISITS TO WORKS.

After the adjournment of the Chemical Section, a considerable number of members and associates went down the Tyne to visit some of the chemical factories. Arrived at Friars Goose, they were conducted by Mr. J. C. Stevenson, M.P., and Mr. France over the establishment, and had the opportunity of seeing the Chance sulphur recovery process in operation. By this interesting method the tank waste from the chemical works is converted into the valuable article of sulphur. The tank waste, which is calcium sulphide—is treated with carbonic acid at high pressure, being converted into calcium carbonate, afterwards utilised in the manufacture of cement. The sulphur combines with the hydrogen, forming sulphuretted hydrogen. This gas is afterwards burnt in specially-constructed chambers, the sulphur being deposited and subsequently cast in moulds, being thus obtained in a remarkably pure form.

After reviewing these works, the party adjourned to the neighbouring works of the Newcastle Chemical Works Company, over which they were shown by Mr. Wilton Allhusen, Mr. Alfred Allhusen, and Mr. J. E. Davidson. The large plant which the company is putting down for the sulphur recovery process is rapidly advancing, and its extent and solidity impressed the visitors, the two ometers for the gases being respectively for 100,000 cubic feet and 30,000 cubic feet, whilst the Dietzsch's kilns and other works are far advanced. From this, the large caustic soda works were inspected, the firm having a speciality in this respect, the caustic soda produced being of the highest strength yet reached, whilst the output of the works is the largest, we believe, in the kingdom. It is anticipated that when the sulphur plant is completed the output of the works will be caustic soda, sulphur, and bleaching powder only.

SECTION C.—GEOLOGY.

CLEVELAND AND DURHAM SALT INDUSTRY.

Prof. G. A. Lebour read a paper by Mr. Marley and himself on the rise and progress of the Cleveland and South Durham salt industry, and on the extension of the Durham coalfield. In 1863, at the Newcastle meeting of the British Association, Mr. Marley read a paper setting forth the then recent discovery at Middlesbrough, in Cleveland, of rock salt by Messrs. Bolckow and Vaughan, in July, 1859. Messrs. Bolckow and Vaughan had been repeatedly warned that they were much more likely to discover salt than fresh water. At 1,206 feet they struck the top of the rock salt, proving it to be 99 feet thick. With that 1863 paper a sample. This was the first public announcement of this great geological and commercial fact. There was then an interval of about 26 years, and now Mr. Marley had been solicited by the Organising Committee of Section C to prepare that paper as an historical account of what had taken place as regarded that rock salt since that time. The very first mention or suggestion of the presence of rock salt in that part of England was made at a considerably earlier date, and the Rev. Mr. Young, with Mr. Bird, of "The Geology of the Yorkshire Coast," suggested the possibility of salt in those red beds. Mr. G. C. Greenwell, an eminent local engineer, in 1853, in his work on "Mining Engineering," also suggested the probability of salt being found in those red leads. In 1863 the British Association visited Messrs. Bell Brothers' bore hole, and in 1881, from York, the British Association had an excursion to Middlesbrough to visit Messrs. Bell Brothers' bore hole. In 1870, Messrs. Bolckow and Vaughan announced that they were about to put down two shafts for the working of the rock salt by mining. That, however, proved a failure. In 1874, Messrs. Bell Brothers proved rock salt on the north side of the Tees, it having hitherto only been found on the south side of the Tees. Messrs. Bell Brothers then adopted the Continental plan of getting the salt out, not by mining, but by brine. Various writers had been engaged in bringing the subject of the salt in these red beds before the geological and engineering public. In 1869 Mr. W. H. Peacock read a paper on the subject. Sir Lowthian Bell, in 1881 and in 1887, spoke on the matter. Other gentlemen who had dealt with the subject were Mr. Thomas Hugh Bell, Mr. Joseph Dickinson, Mr. Thomas Allison, Mr. W. J. Bird, Mr. Edward Wilson, F.G.S., and Mr. Howes, who, he regretted to say, was not present. He

(Professor Lebour) now came to the description of the salt basin. Taking Bolckow and Vaughan's South Bank or Eston boring, so long the deepest boring, as the datum line the rise from South Bank to Greatham was 706 feet, the distance being 3½ miles, South Bank being still the easternmost point of the salt discovered. From South Bank to North Ormesby was a distance of two miles 21 chains, and this was the southernmost point. The southern and easternmost points were clearly not the termination of the salt basin in those directions, and at Lackenby, a mile to the east of South Bank, a boring was now being made. The area of proved salt was at least twenty square miles. A good deal had been said about the boring at Seaton Carew, which was right outside the basin. No one was surprised to find that no salt was struck. The horizon of the salt was struck—the other beds which accompanied the salt was found—but the salt was not there. Another boring put down since the Seaton Carew one was a good deal to the west, at a place called Norton, and which was at present going on. This boring was interesting, both from the salt point of view and also from the extension of the coal field of the future. The upper part of that boring consisted of beds very similar to those in the upper part of the Seaton Carew boring, though not so thick. As the Seaton Carew boring was interesting in proving the greater thickness of the magnesian limestone than they had supposed, the Norton boring was interesting in proving the less thickness of the magnesian limestone than they had supposed. They knew that the magnesian limestone thinned to the west, but he, at least, did not think it thinned so rapidly in that direction. In five or six miles they had a thinning from 800 to 300 feet.

Mr. Marley said to sum up the paper shortly he would show where the salt was known. At South Bank it was 82½ feet thick, and 3½ miles north, at Greatham—which was the northernmost point—it was 82½ feet thick. Between Eston and Greatham they had a rise of one in 200. There was therefore little doubt that between Greatham and Seaton Carew was an actual outcrop of the salt to the north. He had no doubt that South Bank would be found not to be the easternmost point of the salt, as at Lackenby where a boring was now being made in the red sandstone, and everything agreed with the boring at South Bank.

The President said that as regarded the age of those carboniferous beds met with in the deep boring he was quite at one with Professor Lebour in the difficulties which he found in assigning those carboniferous beds to any particular horizon. As every geologist knew, the great carboniferous limestone of England gradually got split up as they passed into Northumberland and Scotland, until in Scotland that carboniferous limestone series was very much like the term red sandstone, and the carboniferous limestone series of Scotland might contain sometimes many thousand feet of strata and only a very few yards of limestone.

Professor Hull, after speaking of the beds encountered at the Seaton Carew boring, proceeded to consider the question whether there was a concealed coalfield between the southern extremity of the Newcastle district and the northern extremity of the Yorkshire coalfield. It was a subject of geological speculation which was interesting to a great many geologists and others, and had given rise to various theories. He should only just state that the conclusion he came to on the subject was one from which he had seen no reason to depart—that was that between the southern extremity of the Durham coalfield and the northern extremity of the Yorkshire coalfield no important concealed coalfield would be found. He thought it very likely that in the eastern part of Yorkshire, bordering on the sea, owing to the dip of the whole of the carboniferous beds towards the east, there would be a fringe of true coal measures there, but it would only be towards the sea margin, and to the west of that he did not think they had any reason to expect any important concealed basin of the true coal measures. The true coal measures there seemed to have been denuded away before the commencement of the mezozoic period.

Mr. De Rance continued the discussion.

Mr. Whitaker said he considered that the most important paper which had been read in that section. There was an aspect of that paper which had struck him—that was the immense amount of knowledge the investigator got from the operations of the borer into the earth's crust.

CIRCULATION OF UNDERGROUND WATERS.

Mr. C E. de Rance submitted the fifteenth report of the committee appointed for the purpose of investigating the circulation of the underground waters in the permeable formations of England and Wales, and the quantity and character of the water supplied to various towns and districts from these formations. The following is an extract from the report: Since your committee were appointed at Belfast, fourteen years ago, the recognition or the great value of our underground water stores has made wide progress, as affording efficient supplies of water to corporations, local boards, and public companies, free from organic impurity, regular in quantity during periods of drought, yielded at a constant temperature throughout the year, and obtained, as a rule, at a smaller cost than gravitation supplies, and almost invariably at a less cost as regards legal or Parliamentary expenses. The publication of the results already obtained by your committee have been greatly appreciated by engineers and contractors, and have undoubtedly helped and supported recommendations of water supplies from underground sources. As time goes on, a large number of borings are annually made, and there being no other recording agency of the results obtained than those collected by your committee, they ask for reappointment; but they note with satisfaction that numerous provincial societies, represented by delegates or the association, are giving attention to this subject, and publishing results, as the Liverpool Geological Society, the Hampshire Field Club, the Hertfordshire Natural History Society. Looking to the comparatively small circulation of the transactions of these societies, your reporter has thought it well to include the more important results so obtained in the present report, as they were obviously the outcome of the suggestions made by Section C as to inquiries that might be taken up with advantage by provincial societies. Your committee, in the present report, almost entirely follow the lines of their first instruction, to inquire into the waters yielded by the Permian and Trias, following those formations from Teignmouth in Devonshire to Tynemouth in Northumberland. Your committee think it advisable to combine the results obtained during the past two years as to the effect of rainfall on the varying height of wells, and to publish them in a graphic form in their report next year, should they be reappointed. The report then gave the results of boring in various places, and proceeded: Yorkshire and Durham:—Professor Lebour states: for water supply purposes it does not appear necessary to notice any of the sub-divisions generally recognised in the Durham magnesian limestone above the marl slate. The following classification gives the important divisions for water supply purposes:—1. Yellow sands; generally a loose, incoherent, coarse sand, with more or less calcareous cement, often concretionary, sometimes solid; very irregular in thickness, from 60 feet downwards, and sometimes absent; contains a large amount of water. 2. Magnesian limestone, resembling that below, generally 6 feet to 10 feet thick, sometimes absent. 3. "Marl slate," a compact, flaggy, dark grey, calcareous or sandy shale, often forming a "fish bed," generally impervious, and a yard in thickness. 4. Magnesian limestone: concretionary, brecciated, compact and cellular; varies from an eminently hard and crystalline condition to an earthy one, and from containing many fossils to none at all. Unconformity.—Red sandstone with coal plants (upper coal-measures). Professor Lebour has mapped the Durham coal-pits, and indicated the outcrop of the Permian series, as well as the position of all sinkings and borings that have been put down to the coal-measures, through the Permian. The numerous sections obtained in boring for rock salt, from Middlesbrough to the district south of Hartlepool, have clearly defined the area where potable water may not be looked for. The boring put down in 1859, for Messrs. Bolckow and Vaughan, was made to procure a water supply for their well-known ironworks. Large supplies of water were obtained from the upper pervious strata; but it contained so large a quantity of sulphate of lime as to be useless for the purpose required, and the boring was discontinued at a depth of 1,313 feet, the details of which are given in the sixth report of your committee.

Since the publication of these details, papers have appeared by Mr. E. Wilson, F.G.S., and Mr. W. J. Bird. The latter author gives a classification of the measures passed through, which is valuable in correlating the various beds passed through, in the sections published and unpublished, occurring in this area. The sequence is as follows, in descending order :—

	Max thickness.
Upper gypseous marls	450 feet.
Red sandstones and marls	1,117 ,,
Lower gypseous marls	279 ,,
Saliferous beds, anhydrite and salt	267 ,,
Magnesian limestone	— ,,
Red and grey sandstone	— ,,
Coal measures	— ,,

Mr. Bird points out that a bed of anhydrite invariably forms the top of the saliferous beds. It is worthy of note that the Zechstein of Saxony contains rock salt alternating with anhydrite. Immediately over the anhydrite is a bed known as the "rotten marl," which occasionally leads to the collapse of the borings. A boring made at Oughton, in 1827, published in the sixth report, is stated to be unreliable, the coal noted as occurring being probably an error. The report also gave the details of a boring about half-a-mile north-west of the Seaton Carew, put down by Messrs. Casebourne and Co., Limited, in 1887, for water for their cement works at West Hartlepool.

LOXOMMA ALLMANNI FROM THE NORTHUMBERLAND COALFIELD.

Dr. EMBLETON read a paper on "The Spinal Column of Loxomma Allmanni from the Northumberland Coalfield." He said the specimen had a longer series of vertebræ than had hitherto been got before from our coal measures. The animal was probably, when living, 14 feet long. Probably it was an air-breathing inhabitant of a lake, probably of warm water. It swam like a fish or newt, and might have been capable of getting on to the dry land and basking in the sun.

BONE CAVES OF CRESSWELL.

Dr. R. LAING read a paper on "The Bone Caves of Cresswell, with the recent discovery of an extinct feline (*Felis brevirostris*), new to Great Britain.

DEVONIAN FISHES OF CANADA.

Dr. R. H. TRAQUAIR read a paper on "The Devonian Fishes of Canada." He did not wish it, he said, to be understood that he meant to speak of the whole of the Devonian fishes of Canada, but only of those from two places.

LITTLE KNOWN BRITISH JURASSIC FISHES.

Mr. A. SMITH WOODWARD, F.G.S., F.Z.S., read a paper on "Little Known British Jurassic Fishes." The following is a summary:—"The remains of many undescribed fossil fishes from British Jurassic formations are preserved in various collections, and the author remarks upon a few of the more prominent types. Some are of genera already recognised on the Continent, but but not hitherto discovered in England. 1. *Eurycormus grandis*, sp. nov. Founded on a well-preserved head from the Kimmeridge Clay of Ely, in the Woodwardian Museum. About twice as large as the typical *E. speciosus*, and differing in the granulation of the head-bones. 2. *Strobilodus suchoides*, Owen sp. As suggested by Von Zittel, the so-called *Thlattodus suchoides*, Owen, from the Kimmeridge clay of West Norfolk, is certainly generically identical with the previously described *Strobilodus giganteus* from the Bavarian lithographic stone. 3. *Hypsocormus Leedsii*, sp. nov., and *Hypsocormus tenuirostris*, sp. nov. The jaws of two new species of *Hypsocormus* have been discovered in the Oxford clay of Peterborough, by Mr. Alfred N. Leeds, of Eyebury. The first *(H. Leedsii)* equals the Bavarian species, *H. macrodon*, in size, and has a similarly obtuse snout; but it differs in the marked obliquity of the two great teeth in the upper jaw. The second species *(H. tenuirostris)* attains about half the size of the first, and is distinguished by the comparative elongation and acutely pointed form of the snout; the two great upper teeth seem to have been directed almost vertically downwards, as in *H. macrodon*. These fossils suggest an interesting comparison between the dentition of *Hypsocormus* and that of the Upper Cretaceous *Prosospyhræna*; two large tusk-like teeth at the base of the snout in each genus being opposed to a pair of similar teeth on each side of the mandible, fixed in sockets in a short, stout, splenial bone. 4. *Leedsichthys problematicus*, gen. et sp. nov. This, probably the largest Jurassic fish hitherto discovered, is indicated by an associated series of bones from the Oxford Clay of Peterborough in Mr. Leeds' collection. It can only be provisionally defined, and may be appropriately named *Leedsichthys problematicus*. None of the bones are externally ornamented, but all have a distinctly fibrous texture. A supposed frontal bone measures 2 feet in length by 1 foot 3 inches in maximum breadth; the hyomandibular is squamous, at least 1 foot 3 inches in length; and the bones of the branchial arches are irregularly <-shaped in transverse section, bearing numerous gill-rakers. The last-named bones are elongated, laterally compressed, slightly expanded at the base, and rarely straight, but irregularly bent and contorted; the surface is coarse and rugose, and one long border is rounded while the other is cleft by a longitudinal median furrow; the rounded border is comparatively smooth, but the furrowed edge is coarsely serrated, a series of short oblique ridges terminating in points on each side. The branchiostegal rays are very large, dense, and rounded in section, in not less than six pairs. The pectoral finrays sometimes attain a length of 5 feet, frequently dichotomously branching, but not jointed; each consists of fibrous bone, appearing as if composed of numerous long, tapering splints incompletely fused together, and the two halves of the ray remain separate. The jaws and axial skeleton of the trunk are still unknown. 5. *Thrissops*. Though not hitherto recorded, remains of the genus *Thrissops* are preserved in the British Museum from the Kimmeridge clay and Portland stone of Dorsetshire; the former equal *T. Regleyi*, Thiollière, from the French lithographic stone. in size; the latter are much smaller. 6. *Browneichthys ornatus*, gen. et sp. nov. Remains of a small elongated fish discovered by Mr. Montagu Browne in the Low. Lias of Barrow-on-Soar, pertain to a new generic and specific type, apparently related to the Belonorhynchidæ. The notochord is persistent, and the neural and hæmal arches are ossified, but there are no well-developed ribs. The scales are thin, cycloidal, with prominent concentric lines of growth, deeply overlapping and externally ornamented with ganoine tubercles. Portions of a dorsal and ventril series of very large, narrow, pointed ridge-scales are also observable. The cranial bones are invested with ganoine, and are coarely tuberculated."

THE DEVONIAN GANOID ONYCHODUS IN SPITZBERGEN.

Mr. A. SMITH WOODWARD read a paper on "The Occurrence of the Devonian Ganoid Onychodus in Spitzbergen." The following is a summary;—In the collection of Devonian fossils from Mimes Dal, Spitzbergen, in the State Museum, Stockholm, kindly shown to the author by Professor Linström, is a small, arched, tooth-bearing bone, indistinguishable from the so-called "intermandibular arch" or "presymphysial bone" of the remarkable Ganoid fish, *Onychodus*. The genus has hitherto only been met with in the Devonian of Ohio and New York (Newberry, "Geol. Surv., Ohio," vol. i., pt. ii., p. 296) and the Low. Old Red Sandstone Passage Beds of Ledbury, England (*Onychodus anglicus*, A. S. Woodw., "Geol. Mag," [3]. vol. v., p. 500). The new specimen thus considerably extends the known range of *Onychodus* in space, and, so far as can be ascertained, pertains to a hitherto undetermined specific type. Four fractured teeth are preserved, scarcely more than half as large as those of the smallest described species, *O. anglicus*, and differing from the latter in the very large size of the internal cavity. The form may be provisionally named *Onychodus arcticus.*

Mr. H. H. Howorth, M.P., who had taken the chair in the absence of Prof. Geikie, spoke of the valuable work Mr. Woodward did in connexion with the British Museum. He thought that the curators of our museums should be allowed more opportunities of visiting foreign collections, so that they would be able to correlate the forms with those they found at home. (Hear, hear.)

The section then adjourned to Section A, to hear Professors Rucker and Thorpe's paper on the relation between the geological constitution of the magnetic state of the United Kingdom.

SECTION D.—BIOLOGY.

"SPECIFIC CHARACTERS."

Professor G. J. Romanes, F.R.S., read a paper on "Specific Characters as useful and indifferent." At the outset he said he would assume that his hearers were all evolutionists, and that all accepted natural selection as a satisfactory explanation of the origin of species. Moreover, for the sake of argument, or rather in order to avoid collateral issues, he would further assume that all species owed their origin to natural selection, and, therefore, that every species must present at least one adaptative or useful character, in virtue of which it exists as a species. On the basis of this assumption there arose the question whether any given species might not present any number of other peculiar characters which were not adaptive or useful, in the sense of being life-preserving, but merely indifferent and meaningless, in the sense of not contributing to the welfare of the species. In other words, were we to suppose that all specific characters — as well as all the species which present them — were due to natural selection; or were we to suppose that some specific characters may arise in any other way, and therefore need not necessarily present any utilitarian significance? On this important question, the opinions of evolutionists were at present divided. To state the question still more closely, by one party it was held that *all* specific characters of *all* species must necessarily be due to natural selection; whereas by the other party it was held that no such necessity obtains—for even if it be allowed that some specific characters of every species are due to natural selection, members of this party failed to perceive the necessity of supposing that *all* the specific characters of *all* species were due to it. It was of importance to observe that up to a certain point a complete agreement existed between both parties. Thus they both accept natural selection as a true cause of the origin of species—they may even accept it as the cause of the origin of all species. They agreed that specific characters were often what is called rudimentary or vestigial, *i.e.*, characters originally produced by natural selection on account of their utility now survived in a dwindling or vanishing form. Moreover, members of both parties were agreed that inability to deduct the use of any given structure or instinct was no proof that such a structure or instinct did not exist. Lastly, there was agreement in holding that a structure which is of use might incidentally entail the existence of some other which was not. Nevertheless, while fully conceding all these facts and principles to the opposite party, those who thought with him were unable to perceive that they constituted any adequate ground for so large an assumption as that involved in the doctrine that all specific characters were due either directly or indirectly to the agency of natural selection. The writer of the paper said it would be his present endeavour to adduce the reasons which prevented him and those who thought with him from accepting this doctrine. The question in debate, he continued, is not merely a question of fact, which can be settled by a direct appeal to observation. If this were the case, systematic naturalists could soon settle the question by their detailed knowledge of the structures which are severally distinctive of any given group of species. But so far is this from being the case that systematic naturalists are really no better qualified to adjudicate upon the matter than are naturalists who have not devoted so much of their time to purely diagnostic work. The question is one of general principles, and as such cannot be settled by appeals to special cases. Our opinions upon this question are really determined by the views which we severally take on matters of general principle. If a man be already persuaded that natural selection is the sole and only cause of organic evolution he is apt to believe that it follows deductively from this persuasion that all specific characters must be due to natural selection; and, therefore, if he cannot suggest any utility as appertaining to any particular characters he is obliged to fall back upon one or other of the two principles just stated—viz., the argument from our ignorance of a possible use or the argument of our ignorance of a possible correlation. On the other hand, if a man is not already committed to an antecedent belief in natural selection as the only possible cause of organic evolution, any such appeal to these arguments from ignorance in the face of any number and amount of otherwise inexplicable cases will appear simply an example of unscientific dogmatism. But, although it is quite true that we cannot determine in fact what proportion of apparently useless characters are or are not really useful, we may very easily determine in fact what proportion of specific characters fail to present us with any observable evidences of utility. Now, observe, we have here a simple question of fact. We are not at present concerned with the question how far the argument from ignorance may be held to apply in the mitigation of such cases. At present we are concerned only with the question of fact, or the question as to what proportional number of cases actually occur wherein we are unable to suggest the use of specific characters, or the useful characters with which these apparently useless ones are correlated. I maintain, as a matter of fact, that the cases in question constitute a large proportional number of specific characters—at all events, so far as animals are concerned; with regard to plants I am not competent to speak. On the other hand, I am accused of betraying ignorance of species, and of the work of species-makers, in advancing this statement; and have been told by several very competent naturalists that there is absolutely no evidence at all to be derived from nature in support of my views. Well, in the first place, one may observe that, if this be the case, it is somewhat remarkable that such highly competent naturalists as Brown, Broca, Nagili, Mivart, Seebohm, &c., should have fallen into the same error as myself. But, in the second place, and quitting considerations of mere authority, I appeal for a solution of this question to the facts of nature themselves, and will now proceed, as briefly as possible, to indicate the results of such an appeal. It has seemed to me that birds and mammals furnish the best field for testing that question by direct observation. It would take far too long if I were now to yield, even in epitome, the results of this systematic inquiry. Therefore I will only state the general upshot. Choosing genera of birds and mammals which contain a large number of species, whose diagnostic characters have been worked out with most completeness, I restricted the inquiry to specific distinctions of colour, not only for the sake of having a uniform basis for comparisons, but still more because it seemed to me that the argument from our ignorance of possibly unknown uses could be more successfully met in the case of slight differences of colour or of shading than in that of any differences of structure or of form. Lastly, after tabulating all the differences of colour which are given as diagnostic of each species in a genus, and placing in one column those which may conceivably be useful, while placing in another column those in respect of which it appeared inconceivable that any use could be suggested, I added up the figures in the two columns, and thus obtained a grand total of all the specific characters of the genus in respect of colours, separated into the two classes of conceivably useful and apparently useless. Now, in all cases the apparently useless characters preponderated enormously over the conceivably useful characters; and, therefore, I abundantly satisfied myself regarding the accuracy of my statement that "a large proportional number of specific characters" belong to the latter category. Cases where uniform and progressive change of climate induces similar or analogous changes of size and colouration throughout numberless species of birds belonging to different genera, families, and orders. We all know in a general way that the bird-faunas of tropical regions differ immensely from those of temperate regions in respect of brilliancy of colouration; and it is difficult to suggest why natural selection should have discovered any life-serving function connected with brilliancy of colour in hot climates, or with dulness of colour in cold ones. More particularly Mr. Allen has studied in detail changes of size and colour among birds of all kinds on the continuous American continent, and he finds a wonderfully close sliding scale of both, corresponding stage by stage with the gradual changes of climate from north to south or east to west, as the case may be. Very reasonably he attributes this to the direct influence of climatic conditions, such as differences in degrees of sunshine, humidity, altitude, and so forth, without reference to natural selection. On the other hand, anybody who rejects this interpretation, and regards all these graduated changes in size and colour adaptive, is unable to suggest the adaptive uses which he assumes, notwithstanding that *en hypothesi* these must be extraordinarily general, seeing that they extend over innumerable species of birds, occupying diversified stations in the economy of nature, and presenting all kinds of differences in their habits of life. Next, I adduce a large number of special cases, wherein the characters of allied species differ from one another in such minute respects of colour or shading that it seems wholly unreasonable to suppose them due to their presenting any life-and-death importance to the birds in question. Lastly, I describe several cases where such minute differences of colour between allied species of birds happen to affect parts of the plumage which are concealed—as, for instance, the breast and abdomen of wood-peckers. There it is most difficult to conceive how natural selection can have operated, seeing that the parts affected are virtually never exposed to the view either of enemies or of prey. Hitherto we have been considering the question of fact as to whether or not it is true that a large proportional number of specific characters do not admit of having their utility demonstrated, or even so much as suggested. In the result I claim to have shown that this question of fact is really not an open question. But although this question of fact is thus really a closed question, there remains the more ultimate question as to its theoretical interpretation. For, as already pointed out, no matter how vast an accumulation of such facts we may collect, our opponents are always able to brush them aside by their *a priori* appeal to the argument from ignorance. In effect they say: We do not care for any number of thousands of such facts; it makes no difference to us what proportional number of specific characters fail to show evidence of utility; you are merely beating the air by adducing them, because we are already persuaded, on antecedent grounds, that all specific characters must be either themselves useful, or correlated with others that are useful, whether or not we can perceive the utility or suggest the correlation. To this question of theoretical interpretation, therefore, we must next address ourselves. And first of all I should like to point out how sturdy must be the antecedent conviction of our opponents if they are to maintain it in the face of such facts as I have adduced. Well, if such be the case, is it not somewhat astonishing that out of 474 differences of colour which are distinctive of the 23 species of the genus *Macropus*, no single one appears capable of having any utility demonstrated, or even so much as plausibly suggested? How robust, then, must be the belief of our opponents in the validity of their *à priori* conviction that all these specific characters must be useful, when in no one case can they perceive the utility? I yield to no one in my appreciation of the unique importance of natural selection; or in the fixity of my persuasion that it has been the main, if not the exclusive cause of adaptations wherever these occur; but to argue on this account that there is no room for the operation of any other principle of change, whether adaptive or non-adaptive, is surely in the last degree extravagant. The unique importance of the theory of natural selection consists in its giving us a *rationale* of adaptive characters; to insist that it must also be made responsible for all the minute changes of form or colour which serve to distinguish mutable species from one another, is merely to weaken the theory by making it carry an unnecessary load of illogical dogma. In short, it clearly does *not* follow as a necessary deduction from this theory that all these trivial details of specific differentiation must be either useful or correlated, unless it has previously been shown that, in point of fact, there is no room for any other principle of change than that of natural selection. This, I apprehend, is the core of the whole question. Therefore, let us next consider the evidence on both sides—namely, first, the evidence which has been adduced to prove, on *a priori* grounds, that there *can* be no other principle of change; and, secondly, the evidence which may be adduced to prove, on *a posteriori* grounds, that, as a matter of observable fact, there *are* such other principles, which are fully competent to explain, without needless assumptions of utility, such minute differences of form and colour as in a large proportional number of cases serve as diagnostic distinctions between species and species. First, then, for the arguments *a priori* (for they are all *a priori*) which have been adduced to prove that there can be no principle of specific change other than natural selection. Disregarding the principles originally suggested by Lamarck—which, even if valid, have no relation to the present question, seeing that they are concerned only with the evolution of adaptive structures—it is alleged that natural selection must occupy the whole field, because no other principle of change can be allowed to operate in the presence of natural selection. Now, I fully agree that this statement holds as regards any principle of change that is deleterious; but clearly it does not hold as regards any principle that is merely neutral or indifferent. If anyone were to allege that specific characters are frequently detrimental to the species presenting them, he would no doubt lay himself open to this retort, viz., that natural selection could not allow such characters to persist. But, where the statement is that specific characters are frequently indifferent—*i.e.*, neither useful nor hurtful—the retort loses all its relevancy. There is no reason in the world why natural selection should interfere with merely indifferent characters, supposing such to have been produced by any of the agencies which we shall presently have to consider. Having quoted from Darwin and Wallace, she said:—Now, such cases prove that even the subtle and inconspicuous causes incidental to domestication are capable of including changes of specific character quite as great as any that in a state of nature are taken to constitute diagnostic distinctions. Yet there can here be no suggestion of utility, inasmuch as the change takes place in the course of only two or three generations, and therefore without leaving time for selection to come into play. So that, upon the whole, in view of these sundry facts and considerations, I do not see that Mr. Wallace's argument touching what he calls the "necessary instability" of useless specific characters, presents any assignable degree of force. And this estimate of its character will immediately be seen to be corroborated by the next class of considerations to which we must now proceed, viz., considerations of the causes other than natural selection, which may be regarded as adequate to induce specific changes of character. 1. *Sexual Selection.* Mr. Wallace rejects the theory of sexual selection *in toto*, and, therefore, nothing that can be said under this head would be held by him to be relevant. The great majority of naturalists, however, believe that Mr. Darwin was right in the large generalisation which he published under this title; and in as far as any one believes that sexual selection is a true cause of specific modification, he is obliged to believe that innumerable specific characters—especially in birds and mammals—have been produced without reference to utility, and therefore without reference to natural selection.

If any one agrees with Mr. Darwin in holding to the theory of sexual selection, notwithstanding this objection from the necessary instability of unuseful embellishments, *a fortiori*, he ought to disregard the objection altogether in its relation to unuseful specific characters of other kinds.

2. *Climate.*—There is an overwhelming mass of evidence to prove that the assemblage of external conditions of life, which we conveniently summarise in the term climate, exercise a potent, a uniform, and a permanent influence on specific characters. Unfortunately, I can only wait to mention a few illustrative cases. With regard to plants, Mr. Darwin adduces a number of facts to show the effects of climate on wheat, cabbages, and other vegetables. Here, for example, is what he says with regard to maize imported from America to Germany :—

> During the first year, the plants were twelve feet high, and a few seeds were perfected ; the lower seeds in the ear kept true to their proper form, but the upper seeds became slightly changed. In the second generation, the plants were from nine to ten feet high, and ripened their seed better ; the depression on the outer side of the seed had almost disappeared, and the original beautiful white colour had become duskier. Some of the seeds had even become yellow, and, in their now rounded form, they approached the common European maize. In the third generation, nearly all resemblance to the original and very distinct American parent form was lost.

As these "highly remarkable" changes were effected in but three generations, it is obvious that they cannot have been dependent on a natural selection ; and the same consideration applies to the still more remarkable results which were obtained so abundantly in De Candolle's remarks on the extraordinary amount as well as "stability" of changes which are produced in the specific characters of plants by changing their habitats from higher to lower levels, &c. All these facts abundantly prove that "climate" alone is sufficient to induce changes in the forms of plants, which may not only be fully equal to those on which specific distinctions are founded, but even very much greater ; and this without reference to the possibility of natural selection having had anything to do with the matter. The same remarks apply to trees. Turning next to animals, the remarkable climatic variations in the size and coloration of birds to which Mr. Gould and Mr. Allen have drawn prominent attention, are met by Mr. Wallace with his customary assumption that all such variations must necessarily be taken to present some hidden use. As it is hopeless to argue against the systematic and express begging of a question, I will not occupy time with these most interesting and highly suggestive facts, but pass on at once to cases where it appears to me simply impossible that Mr. Wallace's assumption as to the concealed influence of natural selection can apply in any degree at all. In an exhaustive memoir on the "Cave Fauna of North America," published within the last few weeks by the American Academy of Sciences, I find the following remarkable statement :—

> As regards change of colour, we do not recall an exception to the general law that all cave animals are either colourless or nearly white, or, as in the case of arachnida and insects, much paler than their out-of-door relatives.

Now, when we remember that these cave faunas comprise representatives of all classes of the animal kingdom, it becomes difficult, if not impossible, to imagine that so universal a discharge of colouring can be due to natural selection. It must be admitted that the only way in which natural selection could act in this case would be indirectly through the principle of correlation. There being no light in the caves, it can be of no advantage to the animals concerned that they should lose their colours for the sake of protection or for any other reason of a similarly direct kind. Therefore, if the loss of colour is to be ascribed to natural selection, this can only be done by supposing that natural selection has here acted indirectly through the principle of correlation. There is evidence to show that elsewhere, in some cases, modification or loss of colour is brought about by natural selection, on account of the original colour being correlated with certain physiological characters (such as liability to particular diseases, &c.) ; so that when natural selection operates directly upon these physiological characters, it thereby also operates indirectly upon the correlated colours. But to suppose that this can be the explanation of the uniform discharge of colour in all inhabitants of dark caves would be manifestly preposterous. For seeing that these inhabitants comprise representatives of all classes in the animal kingdom, from the protozoa to the vertebrata, it would be nothing less than preposterous to suppose that there can be any one set of physiological characters running through them all, modification of which by natural selection entails a corresponding or correlated change of colour. If there were only one class of animals in these caves, such as insects, it would be reasonable enough to surmise that their change of colour is due to natural selection acting directly upon their physiological constitutions, and so indirectly upon their colours. But it would be absurd to suppose that such can be the explanation of the facts, when these facts extend in so similar a form over so many hundreds of species belonging to such different types of animal life. Consequently, these facts can only be explained by attributing them to the immediate influence of the peculiar environment which is furnished by a dark cave. In other words, we are not able to conceive how there can be anything adaptive or utilitarian about this universal discharge of colour, and therefore we can only suppose it due to the absence of light and other climatic conditions having withdrawn from all these animals the influences which elsewhere have been directly concerned in the production of colours. And this appears to me a sufficiently reasonable explanation. Why should natural selection set a greater premium on brilliancy of colour in a tropical than in a temperate zone? Or, to phrase it otherwise, until it can be shown why there should be any diminution of selection in respect of colour as between a temperate and a tropical zone, we must refuse to admit that a total discharge of colour in total darkness is due to the total absence of selection. For, as the case now stands, the most feasible explanation is that in all cases brilliancy of colour is in some way or another directly associated with brilliancy of sunlight—or, in other words, that although everywhere controlled by natural selection, it is also to a large extent an outcome of climatic conditions. Moreover, there is this additional objection to explaining the absence of colour in cave-faunas by the principal of panmixia, viz., that deep-sea-faunas, though equally exposed to the condition of darkness, are not by any means invariably colourless. On the contrary, they very frequently retain their ancestral tints without modification as to brilliancy. As regards dogs, the Rev. E. Everest found it impossible to breed Scotch terriers in India true to their type. Even in the second generation no single young dog resembled its parents either in form or shape. Their nostrils were more contracted, their noses more pointed, their size inferior, and their limbs more slender. Similarly on the coast of New Guinea Boazman says that imported breeds of dogs "alter strangely ; their ears grow long and stiff like those of foxes, to which colour they also incline ; and in three or four broods their barking turns into a howl." Darwin gives numerous facts showing the effects of climate on horses, cattle, and sheep in altering, more or less considerably, the characters of their ancestral stocks. He also gives the following remarkable case with regard to the rabbit. Early in the fifteenth century a common rabbit and her young ones were turned out on the island of Porto Santo, near Madeira. The feral progeny now differ in many respects from their parent stock. They are only about one-third of the weight, present many differences in the relative sizes of different parts, and have greatly changed in colour. In particular, the black on the upper surface of the tail and tips of the ears, which is so constant in all other wild rabbits of the world as to be given in most works as a specific character has entirely disappeared. Again, "the throat and certain parts of the under surface, instead of being pure white, are generally grey or leaden colour," while the upper surface of the whole body is redder than in the common rabbit. Now, what answer have our opponents to make to such a case as this? Undoubtedly, they will answer that the case simply proves the action of natural selection during the best part of 400 years on an isolated section of a species. Although we cannot say of what use all these changes have been to the rabbits presenting them, nevertheless we must believe that they have been produced by natural selection, and therefore must present some hidden use to the isolated colony of rabbits thus peculiarly situated. Four centuries is long enough to admit of natural selection effecting all these changes in the case of so rapidly breeding an animal as the rabbit, and, therefore, it is needless to look further for any explanation of the facts. Such, I say, is undoubtedly the answer that would be given by the upholders of natural selection as the only possible cause of specific change. But now in this particular case it so happens that the answer admits of being conclusively negatived by showing that the great assumption on which it reposes is demonstrably wrong. For Mr. Darwin examined two living specimens of these rabbits which had recently been sent from Porto Santo to the Zoological Gardens, and found them coloured as just described. Four years afterwards the dead body of one of them was sent to him, and then he found that the following changes had taken place. "The ears were plainly edged, and the upper surface of the tail was covered with blackish grey fur, and the whole body was much less red; so that under the English climate the individual rabbit had recovered the proper colour of its fur in rather less than four years!" As previously remarked, it is, from the nature of the case, an exceedingly difficult thing to prove, in any given instance, that natural selection has *not* been the cause of specific change, and so finally to disprove the assumption that it *must* have been. There, however, on account of our historical information, we have a crucial test of the validity of this assumption, and the result is definitely and conclusively to overturn it. If these changes in the Porto Santo rabbits had been due to the gradual influence of natural selection guided by inscrutable utility, it is simply impossible that the same individual animals, in the course of their own individual lifetimes, should revert to the specific characters of their ancestral stock. Therefore, unless any naturalist is prepared to contradict Mr. Darwin where he affirms that the changes in question amount to changes of specific magnitude, he can find no other escape from the conclusion that distinctions of specific importance may be brought about by changes of habitat alone, without reference to utility, and therefore independently of natural selection. In short, this one instance is in itself sufficient to overturn the whole structure of dogmatic assumption against which I am now endeavouring to contend. 3. *Food.*—Although as yet little is definitely known upon the subject, there can be no doubt that in the case of some animals differences of food induce differences of colour within the lifetime of the individuals, and therefore independently of natural selection. Thus, the Brazilian parrot, *Chrysotis festiva*, changes the green in its feathers to red or yellow if fed on the fat of certain fishes; and the Indian gori has its splendid colouring preserved by a peculiar kind of food. The bullfinch is known to turn black when fed on hemp seeds, and a canary to become red when fed on cayenne pepper. Starting from these facts, Dr. Sauermann has recently investigated the subject experimentally. He finds that not only the finches, but likewise other birds, such as fowls and pigeons, are subject to similar variations of colour when fed on cayenne pepper; but in all cases the effect is produced only if the pepper is given to the young birds before their first moult. Moreover, he finds that a moist atmosphere facilitates the change of colour, and that the ruddy hue is discharged under the influence either of sunlight or of cold. Lastly, he has observed that sundry other materials produce the same results, such as glycerine and aniline dyes, so there can be no doubt that a large number of organic compounds probably occur in Nature which are capable of directly affecting the colours of plumage when eaten by birds. Therefore, the presence or absence of such materials in the food-stuffs of birds occupying different areas may very well in many cases determine constant or stable differences of colouration without reference to utility and natural selection. 4. *Isolation.*—It is the opinion of many naturalists who are well entitled to have an opinion upon the subject, that, in the words of Mr. Dixon, "Isolation can preserve a non-beneficial as effectually as natural selection can preserve a beneficial variation." The ground on which this doctrine rests is thus clearly set forth by Mr. Gulick:—"The fundamental cause of this seems to lie in the fact that no two portions of a species possess exactly the same average character, and, therefore, that the mitral differences are for ever reacting on the environment and on each other in such a way as to ensure increasing divergence in each generation, as long as the individuals of the two groups are kept from intergenerating." In other words, as soon as a portion of a species is separated from the rest of that species, so that breeding between the two portions is no longer possible, the general average of characters in the separated portion not being in all respects precisely the same as it is in the other portion, the result of in-breeding among all individuals of the separated portion will, after a number of generations, be different from that which obtains in the other portion; so that eventually the separated portion may become a distinct species from the effect of isolation alone. Even without the aid of isolation, any original difference of average characters may become, as it were, magnified in successive generations, provided that the divergence is not harmful to the individuals promoting it, and that it occurs in a sufficient proportional number of individuals not to be immediately swamped by intercrossing. For, as Mr. Murphy has pointed out, in accordance with Delbreuf's law, "if, in any species, a number of individuals, bearing a ratio not infinitely small to the entire number of births, are in every generation born with a particular variation which is neither beneficial nor injurious, and if it be not counteracted by reversion, then the proportion of the new variety to the original form will increase till it approaches indefinitely near to equality." Now, even Mr. Wallace himself allows that this must be the case, and thinks that in these considerations we may find an explanation of the existence of certain definite varieties, such as the melanic form of the jaguar, the brindled or ring-eyed guillemot, &c. But he thinks that such varieties must always be unstable, and continually produced in varying proportions from the parent forms. Without waiting to dispute this arbitrary assumption, it is enough to point out that it fails even as an assumption in all cases where the superadded influence of isolation is concerned. Here there is nothing to intercept the original tendency to divergent evolution, which arises directly out of the initially different average of qualities presented by the isolated section of the species, as compared with the rest of that species. It is of importance to note that this theoretical conclusion is well sustained by observable facts. For instance, Mr. Gulick himself was led to this theoretical conclusion, not by any deductive reasoning from general principles, but by his own particular and detailed observations of the land mollusca of the Sandwich Islands. Here there are an immense number of varieties belonging to several genera, and every variety restricted, not merely to the same island, but actually to the same valley. Moreover, on tracing this fauna from valley to valley, it is apparent that a slight variation in the occupants of valley 2, as compared with those of the adjacent valley 1, becomes more pronounced in the next valley 3, still more so in 4, and so on. Thus it was possible, as Mr. Gulick says, roughly to estimate the amount of divergence between the occupants of any two given valleys by measuring the number of miles between them. To this solid array of remarkable facts, Mr. Wallace has nothing further to oppose than his customary appeal to the argument from ignorance, grounded on the usual *a priori* assumption that no principle other than natural selection can possibly be responsible for even the minutest changes of form or colour. For my own part I must confess that I have never been so deeply impressed by the dominating influence of the *a priori* method as I was on reading Mr. Wallace's criticism of

Mr. Gulick's paper, after having seen the material on which this paper is founded. To argue that every one of some twenty contiguous valleys in the area of the same small island must necessarily present such differences of environment that all the shells in each are differently modified thereby, while in no one out of the hundreds of cases of modification in minute respects of form and colour can any human being suggest an adaptive reason—therefore, to argue thus is merely to beg an intrinsically improbable dogma in the presence of a vast array of contradictory facts. I have laid special stress on this particular case of the Sandwich Island mollusca, because the fifteen years of labour which Mr. Gulick being devoted to their exhaustive working out have yielded results more complete and suggestive than any which, so far, have been forthcoming with regard to the effects of isolation on divergent evolution. But, if time permitted, it would be easy to present abundance of additional facts from other sources, all bearing to the same conclusion—viz., that as a matter of direct observation, no less than as a matter of general reasoning, any unprejudiced mind will concede to the principle of isolation an important share in the modification of specific characters, irrespective of utility, and therefore of natural selection. 5. *Laws of Growth.*—Under this general term Mr. Darwin included the operation of all unknown causes internal to organisms leading to modifications of form or structure—such modifications, therefore, appearing to arise, as he says, "spontaneously," or without reference to utility. That he attributed no small importance to the operation of these principles may be rendered evident by consulting the last edition of the "Origin of Species." Moreover, even Mr. Wallace acknowledges the high importance of these principles in producing non-adoptive changes of form, and still more so of colour. I have now enumerated at least five causes, or, rather, classes of causes, which are adequate to produce, without reference to their utility, such slight alterations of structure and colour as go to constitute diagnostic distinctions between species and species. The subject, however, is not yet exhausted. Having shown how insurmountable is the *a priori* assumption on which the dogma of specific characters as universally adaptive depends, and having shown how non-adaptive specific characters may arise, we have next to consider the following and very suggestive facts:—If the theory of natural selection is good as a theory of the origin of species, it must likewise be good as a theory of the origin of genera; and if it be supposed essential to the integrity of the theory in its former aspect that all specific characters should be held to be useful, I fail to see how, in regard to its latter aspect, we are so readily to surrender the "necessary" usefulness of generic characters. According to the general theory of evolution, genera are what may be termed pronounced species, just as species in their turn are what may be designated pronounced varieties. Therefore, if the doctrine of utility as universal be conceded to fail as regards genera and all higher taxonomic divisions, it appears to me inconsistent to maintain that it must necessarily hold as regards species. It is not supposed to hold as regards varieties; it is not supposed to hold as regards genera or any of the higher divisions; yet it is supposed to hold absolutely and necessarily as regards the intermediate and particular division of species. Or, otherwise stated, specific characters differ from varietal characters in being, as a rule, more pronounced and more uniform. On this account, advocates of utility as universal apply the doctrine to species, while they do not feel the necessity of applying it to varieties. But now generic and all higher characters are quite as uniform as specific, and only differ from them in being usually still more pronounced, not to say, in many cases, still more generally different over a larger number of organisms frequently occupying larger areas. Therefore, a portion, if for the reasons above stated evolutionists regard it as a necessary deduction from the theory of natural selection that all specific characters must be useful, much more ought it to be a necessary deduction from this theory that all generic, and, still more, all higher characters should be useful. Yet, strange to say, this is not maintained by our opponents. On the contrary, they draw the sharpest distinction between specific and all other characters in this respect, freely conceding that both those below and those above them need not—and very often do not—present any utilitarian significance. I leave to my opponents in this debate the task of justifying a position so transparently illogical.

Professor HERDMAN said he considered the position that specific characters were useful and generic characters not useful to be a very unscientific one. He would be rather inclined to say that generic characters were fully as useful, indeed rather more so, than specific.

Professor NEWTON said he had listened with the greatest interest to the paper of Professor Romanes, and felt very sorry, when he looked back over the last 26 years, to have to think that in all that time we did not seem to have got "any for'arder." (Laughter.) He believed that the chairman himself would be the oldest Darwinian present. His own position on this question was that of a Darwinian of the old fashioned school; and he was quite content with the improvements which Mr. Darwin himself had made upon his original theory—such as isolation, disuse, and that very dangerous doctrine about the law of growth. (Laughter.)

Professor FLOWER said he supposed he might be classified amongst the naturalists who were regarded by a certain school as "old fogeys." (Laughter.) In the address delivered by him a few nights previously, he (Prof. Flower) had given expression to views on this subject which had probably been regarded as tedious amongst the younger school of naturalists, who thought perhaps he was taking a somewhat desponding view of their present position. But he thought the discussions of Friday and that day in Section D seemed to go very far to justify the view to which he had given utterance. The fact was, as Professor Newton had put it, they did not seem to be getting much further forward in this discussion. He had no desire to deprecate discussion, but he did wish to enforce the far greater importance of investigation of the facts upon which arguments must be based. (Applause.) He would like also to enter his protest against the constant use of such terms as specific and generic characters, when what was really meant was major and minor characters.

Professor GEDDES expressed himself to some extent in agreement with Dr. Romanes's general contention, although differing from him on some points of detail.

Professor VINES said he had been carefully following the arguments put forward, but it appeared to him quite impossible to hope that the present debate would provide any of them with a firm and satisfactory assurance on the question at issue. More facts were most conspicuously needed. (Hear, hear.)

Professors Marshall Ward, Hartog, and Cossar-Ewart having spoken,

Dr. ROMANES said his reply would be a very brief one, inasmuch as there had been nothing raised for him to reply to. He wished, however, to correct a misapprehension which appeared to have arisen. Professor Herdman seemed to suppose that he denied utility as being in any degree general throughout species. On the contrary, he did not by any means maintain that a large proportion of specific characters were not useful, and admitted of having their utility demonstrated; neither did he deny that in a large number of specific characters utility, although not apparent, might still be existent; but beyond this he maintained that there were a large number of characters which were useless and might be accounted for other than by natural selection. His whole contention was that Wallace, and those who supported his views, rested their very dogmatic structure on a foundation of sand.

The CHAIRMAN, in proposing a vote of thanks to Mr. Romanes, said he must confess to being one of the class of old fogeys which had been spoken of. There was a question which he had been howling in the wilderness forty years, and to which he could get no answer other than the echo of his own voice, and it was—What is the difference between specific and generic? (Laughter.) As a naturalist, he preferred to look for a solution of their difficulties to the observation of facts rather than by the operation of logic. Professor Newton had alluded to the sins of his early youth—(laughter)—when they had both worked together. Well, he had seen no reason to change the views he then held, although other occupations had prevented him from following out his investigations. He repeated that it was far better for them to be observing facts than wrangling over the difference between specific and generic. (Laughter and applause.)

The thanks of the meeting having been accorded to Mr. Romanes, the discussion terminated.

FISHING BY ELECTRIC LIGHT.

A paper was read on "The Electric Light as a Means of Attracting Marine Animals," by Professor W. A. Herdman, D.Sc., F.L.S. Since the publication in *Nature* for June 7, 1888, of the chief results obtained by the use of the submarine electric light during one of the Liverpool Marine Biology Committee's dredging expeditions, said the writer, I have received a number of inquiries from biologists, fishermen, and others as to the details of the apparatus used, and the exact method of illuminating the tow-nets. Consequently, I believe, it may be useful if I lay before this meeting a brief statement of how the electric light has been employed up to the present time in marine biology, and with what results. The first application of this important method of collecting appears to have been made by the United States Fish Commission in 1884, on board the steamer Albatross. On that occasion an arc lamp was merely suspended above the surface of the water, and it was found to attract amphipods, squids, and young fish to the surface. In the following year the same naturalists experimented further by lowering an Edison incandescent lamp into the water, with similar good results. The Fish Commission do not give any details in regard to the animals collected, nor any comparison between the contents of illuminated and ordinary tow-nets worked at the same time. The next submarine electric light experiments were those carried out by the Liverpool Marine Biology Committee in May, 1888, on board the steamer Hyæna during a three days' dredging expedition in the Irish Sea. The Hyæna, kindly lent by the Liverpool Salvage Association, is provided, for wrecking purposes, with the following electric light installations:— A Gwynne vertical engine, of 6 nominal h.p., running at 300-400 revolutions per minute, works a Phœnix compound wound dynamo, with an effective output of 5,980 Watts (65 volts 92 ampere), at 1,000 revolutions per minute. There are two Pilsen arc lamps of 3,000 nominal c.p. each, which can be used on deck or at masthead or on the side of the ship; four Edison-Swan submarine incandescent lamps of 100 c.p., and ten of 16 c.p. each. The dynamo, being compounded, allows the arc and incandescent lamps to be run together with perfect ease by the use of a resistance of about ·5 of an ohm in the arc-light circuit. The submarine lamps are fitted in strong circular annealed glass protectors, and can be lowered to any required depth in the water by means of a special waterproof flexible cable, made of 260 strands of fine copper wire, covered with thick guttapercha and hemp. The arc lamps require from 25-30 amperes, and the submarine lamps 4.5 amperes, so that there is ample power when the whole installation is running. This apparatus was first used for biological purposes in Ramsay Bay on the first night of the cruise. After dark one of the large arc lamps was hoisted a few feet above deck, so as to allow work to be carried on almost as easily as during the day. We then arranged one of the submarine incandescent lamps in the mouth of a tow-net so as to be just well within the iron ring, and yet not too deeply in the net, the object being to illuminate the entrance to the net and not the middle or tail end. This illuminated net was let down to a depth of three fathoms, and at the same time another tow-net without any light was let down to the same depth over the other side of the ship. When, after half an hour, the nets were hauled in, as the one with the electric approached the surface numerous crustacea were noticed accompanying it, and darting about in the bright light. This tow-net, when emptied into a glass jar of sea water, was found to have contained an abundant gathering, consisting mainly of crustaceans, while the net in the dark on the other side of the ship had practically nothing. The two nets were then put out again, this time to a depth of 6 fathoms, and at a greater distance from one another, with the same general results as before. These two experiments showed pretty conclusively the effect of the brilliant light in attracting the free-swimming animals, the difference between the contents of the two nets being on both occasions most marked. Consequently on the second night in Port Erin Bay, both nets were illuminated, and, while the one was let down close to the bottom at a depth of 5 fathoms, the other was kept at the surface. This experiment was tried three times, with the same result each time. Both nets contained abundance of animals, but the bottom and surface gatherings differed greatly in appearance and in constitution—the net from the bottom containing mainly large amphipoda and cumacea, while that from the surface was characterised by the abundance of copepoda. In April, 1889, the steamer Hyæna was again placed at the service of the Liverpool Marine Biology Committee for a five days' cruise, and the opportunity was taken advantage of to make a further series of experiments with nets illuminated by the electric light. On two successive nights in Port Erin Bay, after dark, both the large arc lamps were lit up and were suspended half-mast high, so as to throw a strong glare upon the water at the sides of the vessel. Tow-nets provided with submarine lamps were then used both at the bottom (6 fathoms) and at the surface, and an ordinary tow-net was dragged round and round the ship in the brightly illuminated water. All of these nets gave abundant gatherings, consisting mainly of copepoda, amphipoda, schizopoda, and cumacea, and differing most markedly from the gatherings taken in the same spot during the daytime without the electric light. In this case there was no difference noticed between the contents of the bottom and the surface nets, both containing abundance of cumacea. This difference from the previous year's results was probably due, I think, to our having a much more powerful surface light (6,000 c.p.) which had been shining for at least half an hour before the tow-nets were put over, with the result that the Cumacea and other bottom crustacea were attracted to the surface from a depth of 6 fathoms. On the last day of the cruise we took a gathering successfully with an illuminated tow-net from a depth of 30 fathoms, the deepest water on our course from the Isle of Man to Liverpool. The results of these experiments in Liverpool Bay have been such as to show conclusively that the submarine electric light is an important addition to the collecting methods by the marine biologist, and one which ought certainly to come into extensive use in the future. As to the practical application of this method to fisheries, although there can be no doubt that the electric light acts powerfully in attracting many free-swimming animals, and especially the crustacea, I think there is no good evidence that it attracts marine fishes; and, although more experiments are required before the matter can be considered as settled, I am inclined at present to agree with the opinion which has been expressed by some of the American investigators, that the method is of more value to the scientific biologist than to the practical fisherman.

"SECRETION OF CARBONATE OF LIME BY ANIMALS."

A paper was read prepared by Mr. Robert Irvine, F.C.S., Royston, Granton, and Dr. G. Sims Woodhead, F.R.C.P., Edin., on this subject. Hens supplied with any salt of lime produce normal egg-shells composed of carbonate of lime. They cannot make shells from magnesium or strontium carbonate. Crustacea, such as crabs, cannot assimilate sulphate of lime from the sea-water to form their exo-skeleton. They can form their shells from calcium chloride. In the egg-shell the organic and inorganic material are both secreted by cells separated from the epithelial cells. In the crab-shell, the organic material (chitin) remains attached to the epithelial cells, and in this the lime salts are deposited, probably by a process of dialysis, whilst in the case of bone, the cells are not epithelial in character, the matrix, though separate, is closely associated with the cells, especially during its formation, and the lime is deposited in the matrix apparently by a process of dialysis. Phosphoric acid, combined with alkalies and alkaline earths, acts as the carrier of the lime salt to the secreting cells. While in the blood, the lime salt is as a phosphate, it may be thrown out mostly as carbonate on meeting nascent carbonic acid at the secreting cells. Lime salts, of whatever form, are deposited only in vitally inactive tissues, such as bone matrix, chitin, or tissues that have undergone degeneration. Although the tissue be dead, deposition may go on. Carbonate of lime may be formed in sea-water as follows: The carbonate of ammonia produced by the decomposition of the effete products of animals, urea, &c., decomposes a portion of the sulphate of lime in the sea-water with the formation of carbonate of lime equivalent in amount to the carbonate of ammonia thus formed.

SOLUBILITY OF CARBONATE OF LIME.

Mr. **WM. S. ANDERSON**, chemist at the Marine Station, Granton, near Edinburgh, gave a paper on "The Solubility of Carbonate of Lime in Fresh and Sea-Water."

DORSAL PAPILLÆ IN NUDIBRANCHIATA.

A paper was read on "The Structure and Function of the Dorsal Papillæ in Nudibranchiata," by Professor W. A. **HERDMAN**, D.Sc., F.L.S.

OTHER PAPERS.

Papers were read by the Rev. Canon Norman on "The limit between the Continental and abyssal marine fauna;" by Professor A. C. Haddon on "The caudal respiration of *periophthalmus*;" by Sir Wm. P. Turner, F.R.S., on "The Placentation of the Dugong"; by Dr. S. Symington on "The Miology of the Gorilla and Chimpanzee"; by Professor G. Gibson, of Louvain, on "The Secretion of Silk by the Silkworm"; and a paper was contributed by Dr. Sims Woodhead and Mr. R. W. Gray on "The Histology of the Stomach of the Narwhal."

SECTION E.—GEOGRAPHY.

MR. CARSTENSEN'S PICTURES.

The **PRESIDENT** announced that, in connexion with this section, there was an exhibition of pictures taken in Greenland by Mr. Rus Carstensen. These pictures had a special value of their own, because they were very faithful reproductions of nature. They had an advantage, too, over photographic pictures, inasmuch as the artist had reproduced with great fidelity the colouring of the icy regions of that part of Greenland. These pictures were very well worth a visit. There was also in the exhibition-room a model, showing the action of the wind with relation to ocean currents. This model was by Mr. A. W. Clayden, and was a most interesting one. In the former, papers that had been read in that section those who had attended the meetings had heard most interesting accounts of the great continents of Asia and Africa. That morning they were going to another continent—that of Australia. He had the honour of introducing to them Mr. Carl Lumholtz. Mr. Lumholtz was a naturalist of marked ability; he was also a close observer of natural and physical phenomena, and had collected a large amount of information concerning the northern part of Queensland.

QUEENSLAND AND ITS ABORIGINES.

Mr. **CARL LUMHOLTZ**, who was cordially received, then proceeded with his address. He said:—Without troubling you with figures I may begin this paper by reminding you that Queensland, one of the youngest of your colonies, is three times as large, in territorial area, as France; and about six times as large as the United Kingdom. I would also ask my hearers to couple with this the fact that this immense territory, which in December, 1859, by its separation from New South Wales, became an independent colony, when with a population of 25,000, is, according to the last census, only now populated by 366,940 souls. The general idea of Australia is mostly confined to gum trees and kangaroos; it is supposed to be a place where there are sheep and cattle on a thousand hills, and where lucky diggers amass immense fortunes in gold mining.

A ROMANCE OF COLONISATION.

What is called the romance of colonisation may be very well worked out in a description of the manner in which this colony was formed. Its capital, as everybody knows, is the city of Brisbane, and there are probably among my hearers men who can remember the rough and ready settlement of Moreton Bay at the time when the colony became independent. This city is now growing by leaps and bounds, and its population has during the last ten years more than doubled. The history of Brisbane is, in short, the history of all Australian cities. Mere shanties of boards and shingle have given place to palatial buildings of stone, and one by one all memories of the old convict-days have departed; so that a traveller landing in Brisbane to-day will find himself in a city of which no nation need be ashamed. The Moreton Bay district and the Wide Bay district, which were the first to be settled, are so well known that I need not take up your time with any description of them. It is a matter of history how the fertile Darling Downs, 2,000 feet above the level of the sea, became occupied in 1842, and how the march of settlement proceeded northwards, creating the ports of Maryborough, Gladstone, Rockhampton, Bowen, Mackay, Townsville, and Cooktown. Nor need I here enter into the question as to whether, by and bye, the north will separate from the south; whether Rockhampton or Townsville will be the capital; and whether on some future day there will be a Northern Queensland devoted to tropical agriculture, with coolie labour localised and recognised. The colonisation of Queensland began, as is always the case, along the coast, where the people have the advantage of fine harbours and navigable rivers, but the adventurous squatter, boldly acting upon the reports of explorers like Oxly, Cunningham, Mitchell, Leichhardt, Kennedy, Landsborough, and Walker, selected runs in the western interior, which it had been the custom to regard as a terrible desert, but which was found to be pastures of the richest description. There were the usual rushes here and there for gold fields. Gradually sugar planting became a remunerative industry; and so, with its minerals, cattle, sheep, and agriculture, the prosperity of the colony was assured. For many years, however, the northern part of Queensland was an unknown land, spoken of as uninhabitable on account of the tropical heat, and as the haunt of the Aborigines, who here were very numerous.

THE WATER SUPPLY.

I may here explain that, although the great want of Queensland is a perpetual supply of water, there are some fine rivers; and these are to a large extent owing to the physical formation of the country. Running more or less parallel with the eastern coast is a backbone of hills known as the "*Great Dividing Range.*" This extends parallel with the coast, at distances varying from fifty to two hundred miles inland, and it forms as a rule the watershed between the eastern and western waters. The summits of this range, although one of these, the Bellenden Kerr, rises to a height of 5,260 feet above the sea, are not so high as the Southern Australian mountains, but this range, by throwing off rain and creating such large streams as the Fitzroy and the Burdekin rivers, naturally makes the eastern part of Queensland more fertile for agricultural purposes than the great western plains. These, although they in the spring present a fresh and green appearance, suffer during the greater part of the year from a considerable want of rain, but provide the finest pastures imaginable. In the western plains the yearly rainfall measures only 10·20 inches, while the southern part of the coast may be 60 and the northern part of the same as an average the double. In one year, in 1886, it amounted at Johnstone River, 18° S. L., to 170, while at Aramac (22° S. L., and in the same longitude) it measured 22 inches. Aramac is 265 miles from the coast.

MARVELLOUS MINERAL WEALTH.

I propose with this brief introduction of the salient points of Queensland geography to talk not about the well-settled districts in which population is numerous on the eastern side of the Dividing Range, but about the much less known downs of the west, towards which settlement is gradually but surely creeping; and of the wilder north, where I had, I think I may say, the unique experience of living for about a year among the Aborigines of Australia. I presume you all have some knowledge of the general products and of the statistics of Queensland, and it will not therefore be necessary for me to explain in detail the almost boundless resources of the country, its mineral wealth, especially of gold, silver, copper, tin, antimony, and mercury. I must however say a few words about a couple of the most celebrated mines out there. One of these, the famous mine at Cloncurry, has, besides its wonderful wealth of gold and copper, mountains of pure iron ore. One of these is 200 feet high, but this colossal mass of iron is almost worthless, on account of its geographical position. The other mine—Mount Morgan—has made Queensland the greatest gold-producing colony in Australia. This mine was discovered in 1884, and is now probably the richest of any in the whole world.

PROLIFIC GOLD MINES.

It is also a remarkable fact that the gold here appears in an entirely new form. Mount Morgan, which is about 300 feet high, has, according to Mr. Jack, the Australian geologist, been produced in the Tertiary period by a hot spring, which may have resembled Iceland's geyser or the hot springs of Yellowstone Park. It is formed of siliceous sinter, with some limonite and clayey substances, and the gold is distributed throughout the rocky mass. This discovery has made the owners immensely rich; the value of some of the original shares exceeding one and a half million pounds. One of my friends who bought a share for £1,000, has now made out of this an income of more than £2,000 a year. By boring, it has been demonstrated that the gold increases in quantity with the depth, so that there seems to be no end of this fabulous wealth. No wonder that it has attracted the attention of speculators in every part of the world. At the present time the weekly output of ore is 1,500 tons. The average yield is 6 ounces per ton, and accordingly £36,000 of pure gold is produced per week. This great find of gold is interesting, both from a theoretical and from a practical point of view. It shows that gold-bearing siliceous sinter can be the result of volcanic agencies, and that there is a hope that gold may yet be found in formations that have hitherto been regarded as worthless.

OTHER TREASURES—PROSPECTS OF COAL PRODUCTION.

The most important source of tin-lode in Australia is found in Queensland, in the Herbertson Tin Mines. Some present may remember that the exhibits at the Indian and Colonial Exhibition (1886) in London showed that even such marketable stones as opals are found in fair quality and good quantity. My own impression is that coal will prove to be one of the most valuable products of Queensland in the future. At present there are only two or three fields which are being worked, but the coal of the Ipswich district has been reported upon by engineers as being quite as good as the coals found at Newcastle in New South Wales. The Burrum-Burrum mine between Maryborough and the coast gives us the promise of a good and extensive field. At present, however, this is a source of wealth that requires further development. But the Queenslanders seem to believe in their coalfields, as they a few months ago sought from the Government a duty on foreign coal to protect their own until the means of development have been improved. The time is not far off when coals will be exported from Queensland just as much as coals at present are exported from Newcastle in New South Wales, where scores of large steamers may be seen loading at one time. The mechanical means of loading are most efficient.

A CLIMATE TO CURE CONSUMPTIVES.

The grasses of Queensland are very nutritive, such as the kangaroo grass, the blue grass, and above all the Mitchell grass, which has a remarkable power of enduring droughts, the least rain causing the apparently dry stalks to shoot. Of 360 kinds of grasses in Australia, about three-fourths are found in Queensland. In useful woods, both hard and soft, Queensland is unusually rich. There are in all about 200 different sorts that may be useful. The climate of Queensland, although very hot, is very healthy on account of its dryness, which makes the heat less oppressive. In the winter the sunny days and clear nights for weeks and months together create the perfection of climate. It is remarkably healthy, and many an instance is recorded of consumptives who have been sent away from the old country, and from the other colonies, as it was supposed, to die, recovering their health. European grains and fruit, such as apples, pears, and strawberries, can be grown upon the high-lands, while semi-tropical and tropical fruits flourish in luxuriance in the low-lying districts on the coast. Oranges, mangoes, guavas, loquats, pine apples, and bananas are to be seen in almost every garden. The vineyards of Roma produce grapes equal to those grown in any part of the world. There are, however, very few indigenous fruits. During my whole stay in Australia, I only once found a really delicious indigenous fruit, some kind of yellow, half-transparent fig; the blacks found it for me in the scrubs of Herbert River. But it was so rare that I never met with it any more. Those fruits that have been introduced, however, abound and thrive wonderfully well.

THE AGRICULTURAL OUTLOOK.

The principal product of agriculture is maize, but wheat and oats can also be grown, though probably with not so much success as in South Australia and Victoria. The capabilities of Queensland in the matter of agriculture are almost beyond conception, these will however not be fully developed until an artificial system of irrigation has been established. Queensland, like all the other Australian colonies, suffers from the capricious alternation of droughts and floods, but the colonists are becoming alive to the importance of a water supply something on the principle of the tank system in India, and I find a vigorous system of experiments with Artesian wells being made. On a journey extending over some months which I made to the Diamantina river, in Western Queensland, the idea forced itself upon me, day after day, as I rode in the saddle over magnificent open downs many feet deep, with virgin soil, chocolate or black in colour, that there is a splendid future in store for coming generations, when they have called in the aid of science to supply the water which nature has so begrudged them. If we see what Darling Downs have done for Brisbane, what may not the vast open downs north of Darling Downs do for the whole of the eastern coast, when they have been fully developed by artificial means? I was very glad to learn that, in 1887, water was found on the Barcaldine Downs by means of Artesian wells at a depth of 691 feet 9 inches; it was clear as crystal, and perfectly fresh; but it was very warm, the temperature being at first 120 degrees Fahr., and afterwards cooling down to 101 degrees. The water issued from a pipe of 10 inches in diameter with such force that it carried up stones to the surface of the size of emu eggs. The amount of water from this Artesian well was about 176,000 gallons per day. Other experiments of a similar nature have been carried out with success, and as a further example of what can be done, I may state that at Blackall in 1888 an Artesian well was struck at 1,663½ feet, giving out water at the rate of 300,000 gallons per day, of a temperature of 119 degrees. In other places several borings have been successful at a very shallow depth.

CHINESE LABOUR.

The most interesting portion of my residence in Australia, where I was sent by the University of Christiania to study the fauna and the Aborigines of the continent, was spent in the north-eastern district of Queensland, close to the coast. Here I remained fourteen months, constantly travelling and studying. The great cry of Australia is "Australia for the white man," and in Queensland I found that repressive measures had been taken by the Legislature in response to public opinion which demanded that the immigration of the Chinese should be checked and the importation of Kanakas from the South Sea Islands should be discouraged. Consequently the immigration of the Chinese and Polynesians has considerably decreased of late years. In 1883, 2,951 Chinese emigrated to Queensland, while in 1887 there were only 307. The number of Polynesians arriving in Queensland in 1883 was 5,276 and in 1887, 2,079. This is a sore point with the Queensland colonists; the white working men in the southern portion strongly objecting to the cheap labour of the Chinese. Kanakas, or coolies. The repressive measures to which I refer have had the effect of almost crippling the once-flourishing sugar industry, and I have no doubt myself that in the tropical portions of the colony, where sugar, tapioca, spices, chinchona, coffee, arrowroot, and probably tea, may be profitably grown, coolie labour will in the future have to be largely employed; for, although it is possible for white men to work in the open air at all periods of the year, as a matter of fact the cultivation of sugar cane is not a work in which they are willing to engage. India is only twenty days' sail from the north of Queensland, and sugar cultivators are looking forward to the time when the surplus labour of the Indian dependency will be encouraged upon sugar, and perhaps cotton plantations. I may here say that the general opinion is that sugar will also be grown round the shores of the Carpentaria.

THE ABORIGINAL RACES.

But my principal studies were confined to the unfortunate Aborigines of the continent, said to be the most degraded and hopeless of all savage races. As I intimated just now, I lived among these people, adopting as far as I could their mode of life, and making myself acquainted with all their manners and customs. I camped with them in different districts, the only white man amongst them, and as far as I know the only white man with whom some of these tribes ever came into contact. I was able to study these savages, young and old, and was fortunate enough to collect for the science of Ethnography facts concerning them of which little or nothing hitherto has been known. The Australian Aborigines are rapidly disappearing, and probably within a generation or two they will, like the Aborigines of Tasmania, have vanished altogether from the face of the earth. The base of my operations was the Herbert river under 18° S. L., and from my headquarters, Herbert Vale, I made expeditions in various directions, extending in some instances to nearly 100 miles. Of the 50,000 natives that are supposed to be living in the whole of Australia, probably from eight to ten thousand inhabit this northern portion of Queensland, but all efforts to obtain correct returns as to the numbers of these people have been unavailing. I could not of course go at once to live with them, but had to work my way carefully, having, during the previous year, in the more settled districts of the colony, acquired some experience as to how to deal with them. The natives living immediately round my headquarters at Herbert Vale were partly civilised, and I accompanied them on their hunting expeditions, witnessed their fights and dances, and grew familiar with their language and customs until I felt I could venture further inland, to mingle with the real savages. I need not say that great were the difficulties and even dangers in my path, but luckily I had a large supply of tobacco, which was the only means by which I was able to pay and conciliate my naked friends. Every night, by firing off my revolver before I retired to rest, I kept alive in their minds the impression that I had the means of defence with me.

I used to live in huts the same as those used by the natives, and which could be built up in a few minutes from boughs of trees and palm leaves. I had my hut made so long that I could stretch myself at full length, while my people used to huddle together two or three in a hut, in order to keep themselves warm, their feet projecting outside the opening. Although I lived on terms of perfect friendship with them, I never gained their gratitude; but found that, when the novelty had worn away, their friendship decreased; and at last they were only waiting for an opportunity to take my life. That I was able to take my leave of them without a breach of the peace, and as a living man, I deem an especial piece of good luck.

THEIR LOVE OF TOBACCO.

During my travels I was fortunate enough to find a really good black fellow of the Northern tribes, who stuck to me wherever I went. My general plan was to form a camp at the foot of the mountains, leaving the horses behind hobbled; to place the saddles and bridles in a tree, so that the dingoes (the Australian dog), could not get at them, and then ascend the mountains on foot, pushing through the dense underwood, and carrying a small supply of ox flesh and wheat flour for provisions. When this store was exhausted, which occurred very soon, I lived like the Aborigines, on snakes, lizards, larvæ, eggs, &c. The most important item of all my outfit, however, was tobacco, of which the Aborigines are inordinately fond. They would accept it as money, and exchange even their wives and daughters for it. These tribes would often send to distant tribes small bits of tobacco, wrapped up in gum leaves or grass, as recognised objects of barter. It is quite remarkable that, in this way, the use of tobacco is known among tribes who have never themselves come into contact with Europeans.

THEIR CHARACTERISTICS.

It struck me that the Aborigines with whom I thus mingled on the Herbert River were a very mixed race of people physically, for while some were tall and well-shaped, there were others of a smaller and weaker stature. Nearly all had the ordinary flat, triangular noses, but I found several with almost Roman noses, indicating an inter-breeding with the Papuans, who, it is well-known, are very proud of their prominent noses. There is no kind of unity among these people, for they are divided into a number of tribes, and their languages appear to be as diverse as themselves; though on closer examination it appears that all the languages are in some measure related to one another, so that they may properly be styled dialects derived from one common source. Of a written language there is no trace; nor do these aborigines cultivate the ground, or keep any domestic animals, except an occasional dingoe. They have no instruments or weapons better than the rude axe, tomahawk, boomerang, spear, club, wooden swords, and shields; the boomerang is not used further north than the Herbert River, the dense scrubs which exist, as one gets further north, making superfluous a weapon which requires a clear space of about hundred yards for operation.

The black fellows almost exclusively use spears in hunting on the grass lands, but when they are walking in the extensive and thick brushwoods of the north they move about perfectly unarmed. If they get a glimpse of any animal, they break off sticks, and try to kill the animal by throwing sticks or stones at it. Herein they generally succeed, as most of the animals live in trees and have a great difficulty in escaping when the natives from several sides climb up and encircle them. When an animal has been slain and is to be prepared for food, the belly is opened by the first stone or piece of wood found suitable for the purpose. The game is divided for distribution either with a stone or with the teeth, which are also largely used for breaking off limbs of trees and for making implements. The knives used by the blacks are either pieces of stones found ready for use, or they are secured by breaking pieces off the rocks, little additional labour being bestowed upon them. The Australian native is in reality not very far advanced in the Stone age. The mutual relationship of the different tribes is still, on the whole, that of the lowest grade of the human race. They are polygamistic, and a man's riches are judged by the number of his wives, who have to do most of the work. I found no chiefs among the tribes on the Herbert River. They have no religion, and they acknowledge no discipline; personal liberty is never interfered with; they, in short, roam the forests, climb the mountains, and live from hand to mouth upon roots and such live creatures as they can kill, perfect types of the wild children of nature.

CANNIBALISM.

They are fairly kind and friendly among themselves, hostile to strangers, and given not only to killing, but to eating their enemies. Of this there is no doubt whatever. I do not say that all tribes of Australian Aborigines are cannibals, but in the north they make no secret of it, and this is a fact well known to the white settlers. One of the standing themes of conversation among my people around the camp fire was how best to procure *talgoro*, or human flesh; and there was one old woman who had quite a reputation on account of her cleverness in procuring, with the aid of her husband, that very much coveted delicacy. It must not be supposed, however, that the Aborigines indulge in human flesh every day. They like it as a matter of preference, thinking it better meat than the flesh of the wallaby or the snake. It is their tit bit, and they have an idea that by eating the fat round the human kidneys they will be invested with the strength of the dead man. They are also fond of carrying little bits of human fat wrapped up in grass, in one of their baskets slung round their necks, believing that such a talisman will ensure them good luck in their hunting expeditions. It was during the latter portion of my sojourn a consolation to know that my friends had a strong dislike to the flesh of white men, declaring that it gave them the nausea. They prefer the flesh of people of their own colour; and it seemed pretty certain that, though my life might be treacherously taken, I should not be served up for a meal. It had been arranged that I was to be quietly dropped into the river. It is not because they would like to eat you that they are dangerous to associate with, but because they want to possess what you have. A black fellow will kill a white man for a pipe of tobacco. It is not often that an opportunity presents itself to obtain talgoro; during my whole stay at Herbert River only two blacks were killed and eaten. One was a young man who had ventured into the territory of another tribe; the other an old man who was not able to escape quickly enough when his tribe was attacked, and so he was beaten to death with stones and his flesh was brought to Herbert Vale in baskets.

A DOOMED RACE.

On the whole, I agree with those who think that the Australian blacks cannot live under civilisation; they will not give up their old nomadic life; they seem doomed to adopt, not the virtues and advantages, but only the vices and evils of civilisation, and within not very many years a whole race of people will have succumbed to the inexorable fate of hopeless extinction. Some of the Aborigines have been sufficiently civilised to make good shepherds or stockriders, or to be formed into "native police." (The latter, of course, are the natural enemies of those against whom they are used). But although the Australian native may advance so far in civilisation as this, it is a characteristic fact that he can never get into an independent position. He never lays anything aside for future use, and does not know how to make money. He never learns how to become a trader, and he retains, when civilised, the decided disinclination for farming so characteristic of him in his natural condition. Not even in the easily-earned income that may be derived from grazing does he understand his own interests. A living sheep is an impossibility in the camp of the blacks; they would most assuredly eat it at once; the gold of the country is nothing more than a stone for them, even if they see the greedy digger grow rich by the search for this precious metal. Therefore, on the whole it is impossible to resist the conclusion that advancing civilisation is beyond their power, and that they will remain without future, without hope, without home; in other words, they are a doomed people.

THE FUTURE OF QUEENSLAND.

The well-appointed agencies of the various colonies in London, the exhaustive information furnished by the literature which arose out of the Indian and Colonial Exhibition, and by private individuals such as Mr. Bonwick, Mr. Bailey, and others, and by the articles in the valuable weekly paper the *Queenslander*, will have given us much information with regard to the progress made in Queensland as well as in other colonies, with regard to railroads, harbours, electric telegraphs, and other practical works undertaken by the respective Governments. The history of Queensland, the youngest of the Australian colonies, like the history of the others, has been to establish communities which possess the vigour of youth and European culture combined. It is very marvellous that these results have been achieved in two generations; and if we could visit Australia two generations hence we should probably find a country where not only European flora and fauna have invaded and conquered large districts from which they have been excluded since the Tertiary period, but where every trace of the original population will have disappeared. Instead of the stagnation of a thousand years of the first stages of the Stone age, we shall have a vigorous development parallel with the culture of Europe and America. In the whole history of man a more sudden revolution is not known than that which has happened in Australia during this century; and Queensland, with its wool and cattle, its semi-tropical and tropical riches, with its ability to produce sugar of high quality in any quantity, with its extraordinary yield of precious minerals, such as that which makes the Mount Morgan one of the wonders of the world, apart from the hopeful character of its coalfields, with its good harbours, with its seaboard of 2,500 miles, with its healthy climate, with its free education, and many free institutions for the benefit of its people, is nobly fulfilling the aspirations which have made the Anglo-Saxon the most successful colonist of all ages, and justifying the most sanguine hopes of the pioneers of Australian colonisation.

At the conclusion of the paper, a hearty vote of thanks was passed to the author on the motion of the President, who said that Mr. Lumholtz, in his account of the aborigines of the country, certainly presented a very sad picture. He had mentioned, among other things, the presents of tobacco that they sent from one district to another. The same custom was to be found among the natives of British North America. If ever they wanted to get up trouble or create disturbances, they first propitiated some other tribe with a present of tobacco, which showed the influence of tobacco over uncivilised natives. The other side of Mr. Lumholtz's picture was certainly an augury of a happy future for the colony of Queensland.

Mr. LUMHOLTZ, in acknowledging the vote of thanks, said that comments had been made in the *Daily Chronicle* with reference to his statements on the subject of cannibalism. He hoped the paper he had just read might prove a sufficient answer to those comments. He knew of one instance where a white man saw a baby about three weeks old roasted on the coals and eaten. There was a horrible case about one hundred miles south of Herbert River—a case well-known to all the white population there. It was a case of a child of two years of age, who was taken ill and eaten by the members of the tribe, and even the mother partook of the meal. The mother was subsequently taken ill and died, and she also was eaten. He had once had a conversation with a native girl who was in service. There were two girls, to one of whom he was talking as she was standing smoking her pipe, and this girl told him how her friend had had three children, but as she was in service they were a trouble to her, so she killed them. "The last one I killed," she said, "I put my foot on her chest." He asked her if she had eaten it. "Yes," was the reply, "and the mother eat some of the child too." He had been told by Mr. Chan Toon that the hill tribes of Burmah were something like the Australian aborigines—regular cannibals. They used to collect the blood of their enemies in bamboo sticks. These they hung for a time in the huts, and on certain festival occasions the chief would order these bottles to be taken down and the congealed blood to be divided among all present. It was quite congealed, and like cheese. They all liked to have something of this substance, and they thought they gained the strength of their enemies by eating it. His object in referring to this instance was to show that cannibalism existed elsewhere than in Australia. In Borneo and in the interior of Africa it still existed.

BRITISH NORTH BORNEO.

The next paper was one by Mr. Alexander Cook on "British North Borneo." This paper traced in detail the development of North Borneo under the action of the British company under whose care it is placed. The author described the various natural and introduced products, and adduced data to prove how rapidly the commerce of the region had developed.

PERU AND BOLIVIA.

The next paper was one by Mr. H. Guillaume on "Recent Explorations in Peru and Bolivia." He said :—Having been invited by the secretary of the Royal Geographical Society to impart the information he had received respecting the recent explorations in Peru and Bolivia by Col. A. R. P. Labre and others, he very willingly acceded to his kind request. Col. Labre, between the years 1872 and 1885, had endeavoured to open communication from the Purus to the Beni. He explored the river Ituxy and its affluents several times, and he has supplied us with new geographical information respecting it. He received great help from the Hypurina nation in constructing a road. The reader gave an interesting account of the Labre travels, and went on to deal with those of Cadre Armentia, who visited these regions about 18 months previous to Colonel Labre, and who favourably referred to the efforts of Colonel Labre to open means of communication to the Beni. The explorations of Colonel Labre and Señor Armentia on the Madre de Dios and the opening of that river to commerce would, he said, greatly benefit those remote regions. Proceeding, finally, to the travels of Señor Carlos Fry of Cuzco, they referred to the Ucayali and its tributary the Urubamba, which formed the great artery to the interior of Peru. Respecting the Indians, the first they met were the Campas. They occupied the margins of the Urubamba and Bambo rivers. They are very friendly with the whites, who had taught them trading, which has been the most powerful agent in civilising them. They greatly appreciated the blessings of civilisation. The Piros (he continued) dwell on the Lower Urubamba and Upper Ucayah, as far as Sibunya. They are very peaceable, trading with the whites and working for them. As canoemen they are without rivals. The women dye the hands and feet black, to imitate the gloves and boots of the whites, with the huitoc root, which also cures eruptions of the skin. The Conibos and Shipibos dwell on the banks of the Ucayali, they are very peaceable, appreciate civilisation, wear European garments, speak Spanish and Portuguese, and are very intelligent. They imitate the whites in exchanging visits ; when entering their dwellings they offer one a seat and shake hands, drinking health with ceremony. But, unfortunately, they still retain some of their savage customs. They compress the heads of their children between two small boards, causing the head to assume a conical shape ; the deformity of some of the skulls found in the ancient Huacas (burying places) may be traced to this custom. The other barbarous custom is that of interring fretful children alive, the mother herself making a hole in the ground, and burying them. If one of their family fall ill, they hold a council, and usually conclude amongst themselves that he will not recover, and make no effort to restore him to health. The gradual extinction of the aborigines of these regions may possibly be attributed to this custom.

THE UPPER NILE.

Mr. E. G. Ravenstein next read a paper on "Geographical co-ordinates in the Valley of the Upper Nile." He discussed the latitudes and longitudes observed along the Upper Nile, and especially those of Major Watson, R.E., and Col. Mason. He showed how certain modern maps, including that of Dr. Junker's travels, had been vitiated in consequence of these results being either neglected or misinterpreted.

CAPTAIN WIGGINS'S SIBERIAN EXPEDITIONS.

The next paper was one on "The resources of Siberia and the practicability of the northern sea route," by Mr. Sulivan. The paper was as follows :—

In considering the question of opening up any new field of trade, we should consider : 1. Whether there are reliable and inexpensive means of communication. 2. Whether there is a profitable commerce possible with the country, a demand for our goods, and a supply of produce that the country can give us in exchange. 3. Whether there are likely to be obstacles or facilities put in our way by the inhabitants and government of the country. If these three questions can be favourably answered, then there is scope for enterprise, and success will depend upon the capital at the command of the adventurers, the ability with which they conduct their operations, and the perseverance, patience, and energy with which they meet the difficulties, disappointments, and temporary failures that are sure to arise in the early days of any undertaking. From the days of Willoughby, in 1550, a north-east passage has been the dream of many navigators. The Norwegian fishermen were in more recent years attracted by the walrus fishing toward the Kara Sea, and penetrated that water. Captain Wiggins, as is well known to most of you, for many years held the idea there was a possible open route to Siberia in this direction, but he had not, at first, means at his command to carry out his idea. At length, in '74, Wiggins was able to fit out an Arctic steamer, the Diana, cruised two months in Kara Sea, reached the mouth of the Obi and Yenisei, came back to England announcing the route was open. Besides being practically the first navigator to reopen the door to these regions, he is the only navigator who has persevered, and so many as five times carried out successfully, so far as the sea route is concerned, the only man who has stuck to the work, the one who has, I believe, most clearly solved the problem of navigating these waters with certainty every summer. Much as I should like to follow all the expeditions that followed Wiggins, I can on this occasion merely enumerate them. 72, Diana s, Wiggins ; 75, sail, Proven, Nordenshjold, Y ; Whim, Wiggins ; 76, Thames, Wiggins, Y ; 76, Ymer, Nordenshjold, Y ; 77, sail, Zaria, Yenisei, Europe ; Louise, Obb ; Fraser, T. ; 78, Warkworth, Wiggins, Obi. Nordenshjold—Vega, N.E. ; Lena, Lena ; Fraser, Yenisei ; Express, sail, Yenisei ; Neptun, Obb ; Sibir, Tjumen, Europe ; Moscow, Yeniseisk. This shows five years of consecutive practical navigation by sixteen vessels. In 1879 we come to the first failure. Against Wiggins urgent entreaties, the merchant he took to the Obb in the Warkworth, chartered five large iron steamers totally unfit to meet any ice. They reached the Kara Straits, which were then blocked by ice, and after waiting a few days returned to England. But three days after their departure the ice all cleared away, and the Louise, which was also there and had waited, went through to the Obb and back again, thus showing the work could be done even during such a year when there was more ice than usual. 1880. Neptun and Louise to Obb, and Yenisei. Siberiahoff lost Oscar Dickson through mismanagement. 1882. Varna, sailing ship, got beset. St. Hovgaard Danish steamship Dymphria, seeing Varna in the ice, went into the pack to reach her, and got beset himself. He afterwards announced that had he not left the clear waterway, he could easily have reached the Yenisei in 1882, and again in 1883 after he was freed that summer. His observations during the winter spent in the Kara Sea show that even in winter this sea is not frozen over, for the pack he was beset in drifted here and there during the whole period. In 1883 the Luise also got to the Obi, but she lost her funnel in a gale, could not steam, and was stranded on a sandbank in the Gulf of Obb. Thus we have, over 10 years, the record of 19 successful voyages, the failures unimportant. There were two or three attempts made by Siberiahoff and another ship, I think the Luise, which did not succeed, but I firmly believe these failed more through unskilful navigation and through ignorance of the set of the ice in these parts than through any impracticability of the route.

Summing up the results of these expeditions, I fully believe that Wiggins's theory is well founded. The results lead us to this conclusion. The Kara Sea itself offers little difficulty to navigation, although sometimes the straits leading to it may be temporarily blocked by ice when long-continuous north-easterly winds have collected the ice and driven it down into this corner, whence it has little room for exit. The work should not be attempted without proper Arctic steamers, so that a passage may be forced on occasions that iron steamers would be turned back. Besides the effect of butting a piece of loose ice during dark or fog would probably be fatal to an iron steamer, harmless to a wooden one. A knowledge of the general movements of the ice in the Kara Sea is necesary. On temporary closing of these lower straits, some ships have taken the Matolsclchin Straits, with sometimes good, sometimes bad results. Wiggins is against this route, and from the accounts of some attempts I am led to think that there is often, but not always, ice akin to the middle path of Baffin's Bay, which prevents ships coming through this strait crossing the Kara Sea, whilst there is free passage from Kara Straits and always open water down the east side of Nova Zembla. Mr. Gardiner found this in 1876, when Wiggins and Nordenshjold crossed without opposition. Again, although I fully believe in the possibility of every year crossing the Kara Sea, I think we might round Nova Zembla. I sailed with Capt. Wiggins in 1887 on 5th August for the purpose of superintending the commercial arrangements, and for inspecting the country. We saw no ice, but on one occasion, and with our steamer drawing 11 feet water, without much difficulty ascended the magnificent river. We fortunately picked up a young doctor at Dudinha, who offered his services, and as he spoke French we were able to communicate in a roundabout way with the fishermen, who acted more or less successfully as indicators of the channel. Coming to the village of Silivaneka, where the religious sect of the Scoptzi dwell, we decided to leave much of our salt here. We heard that there was a difficult pass at the junction of the Tungoos River, and that there were cataracts and very little water —only 5ft. We discharged half our cargo, lightening to 8ft., and there was a great desire to put out all, but I did not care to take only an empty ship to Yeniseisk, and decided we would keep the rest on board—at any rate, until we found we could not get on. We heard of a certain pilot who had discovered a new channel, and I went up two days steaming in the launch, with the doctor, to procure the services of the man. Fortunately finding him, we quickly ran down, the pilot on the way sounding over a ridge of rocks. The shallowest part of the river over which the pilot Nesta said there was usually only 8ft., but owing to the greater height of water that year we found 12ft. Coming to the steamer, we then began a task which taxed the skill and steadiness of captain and crew and the strength of our engines. The Yenisei here passes through high rocks, on the top of which the wrecked timber showed where the spring flood sends the ice among the trees. The centre channel is deep, and the stream runs fully seven knots, according to Captain Wiggins's calculation. The local steamers have not sufficient power to stem this current, and, being of light draft, take a five foot channel inside some islands, where the stream is much slower. No one had ever been down the main channel, which was believed to be encumbered with rocks, forming cataracts, until Nesta bravely ran down in his boat and found a deep-water channel. The swirling of the water caused by the swiftness of the current perhaps gave the idea of the cataracts. Slowly the Phœnix, with engines working their utmost, stemmed the current, and soon we could boast of having taken the first steamer up this main channel. Our good friend Nesta then left us, and we went on in our usual way until we had accomplished the 1,500 miles of river to Yeniseisk. I cannot stop to dwell upon the interesting features of our journey. The river, at this distance from the sea, is a mile broad, and forms a water highway unsurpassed, I believe, in the world, for it is navigable almost into Chinese territory. I may here mention that the failure we experienced last year was not caused by any impediment in the Kara Sea, but solely through the grounding of the Phœnix in the Yenisei. We were informed that she could not be got off. We have calculated the chances of such an accident, but could not procure the necessary funds to guard against it, as we desired, by sailing with the Labrador, a second tender, with which to tow a barge with our cargo up the river, should the Phœnix not meet the sea steamer at the mouth. When the accident happened I then was able to pick up and send out a paddle tug passenger boat, but this caused a month's delay. In a gale the steamers separated, and missing each other at the rendezvous, the tug Seagull returned to Vardo. Meanwhile the Labrador found some ice in the straits, but after the lapse of a few days this all cleared away, and she went easily in to the Kara Sea, which she found quite open. The walrus vessels reported that they had been as far north as the 75th parallel in open water. Captain Wiggins did not go on to the mouth of the Yenisei, which he could easily have done. It was then the 26th September, and late in the season, and no object would have been gained but the proving of the openness of the route, about which he had quite sufficient evidence already. We have quite recently formed another little syndicate. The Labrador sailed on August 5, and we have chartered the light draft paddle steamers of the Russians to convey our goods on the river. I hope we may hear soon of complete success. I received on Saturday the following telegram from Consul Holmlve at Vardo, who has, doubtless, received intelligence from some returning walrus sloop :—"Straits Kara Sea penetrable; Labrador probably Goltcheeka." I will now give some brief account of the country itself. To say that Siberia contains 5½ millions of square miles may convey no real impression to your minds. Look at any map. Then you will begin to take in its vast size. From the North down to about the Arctic circle we have the treeless Tundra, covered in winter with nearly 10ft. of snow, the ground in summer thawing but to the depth of 12in. Yet this region is carpeted in summer with numerous flowers. The natives roam it with their herds of reindeer, ever wandering in search of fresh moss. Next we come to the forest region, extending for hundreds, nay, thousands of miles. The trees met with are the larch, the cedar pine, the white birch, the lime tree, and mountain ash. The furs of Siberia are many of them more highly prized than those of North America. We have the white and brown bear, the white and blue fox, the wolverene, badger, polecat, sable, ermine, weasel, otter, beaver, grey squirrel and flying squirrel, and chinchilli. Do not imagine that the treeless "Tundra" or the wooded "Taigar" contain no hidden wealth. Gold, graphite, copper, coal, or at least a valuable lignite, are known to exist in many places accessible to our barges on the Yenisei and exploration will doubtless reveal many deposits elsewhere. As the African ivory becomes more ard more scarce, so will the fossil mamoth ivory of the north increase in value. But the real wealth and the more habitable and populated region begins with the northern limit of cultivation about the 60th parallel. No district in the world will beat in productiveness the upper watershed of the Obb and Titish. The Steppes nourish enormous quantities of cattle, sheep, and horses. The main centres of the grain districts are at Barnaoul and Semipaulatinsk on the confines of China, and the produce is conveyed in barges down the river to Tjumen, a far greater quantity than most people have any idea of finding its way to Europe, even to London. The chief grains are wheat, barley, oats, rye, buck wheat. Hemp, flax, and their seeds are exported in large quantities, likewise potatoes. In the Newcastle Natural History Museum are 400 fine specimens of Siberian mineralogy, presented to the town by the late Emperor Nicholas. These come chiefly from the Urals, Ekaterineburg being the centre, the wealth of which I will not attempt to describe. The next important centre is Barnaoul. Great quantities of silver and copper are here found and melted. 40,000lbs. weight of silver annually is sent to Petersburg from Barnaoul, from which 3 per cent. of gold is extracted. The third centre is Nertchinsk, producing, besides gold, silver, iron, antimony, arsenic, tin, and lead. Precious stones abound throughout Siberia. Whilst these named centres are the chief, many other important mineral districts exist. On the Upper Yenisei are ironworks, the ore smelted by charcoal. These ought to be the main sources of supply, if properly worked, of Eastern Siberia. But they are in a most neglected state owing to want of capital. The manager of the Government Bank at Krasnoiarsk said to me, "If you English would only come out and work our minerals, you would make more money than is made in gold mines. Local capital will only be put into gold works, hence our other minerals are quite neglected. When it is stated that Siberia produces one-tenth of the gold of the world, the purchasing power of the country can be imagined. Whereas many of the mines are Government property, many are private. The discoveries of Welsh gold are hampered by a tax of, I believe, 30 per cent. The Russian Government exacts only a tax of 3 per cent., but Government takes, and is responsible for the safe conduct of, all the gold produced, giving the mine discoverers fair credit for it.

Captain Wiggins and myself drove 100 miles to some of the Yeniseish mines. We saw them in winter time, and therefore at a disadvantage, but there was abundant evidences of prosperity in the state of the works and dwellings. Never shall I forget the silent beauty of those drives, under the full moon, through forest cuttings so narrow that the wind found no entrance, and so the giant fir trees sustained a weight of snow that added an indescribable beauty to the scene. The stillness of the forest was unbroken save by the music of the bells. That we were upset ten times during the first night did not spoil the impression. I would undergo the mishaps again for the same treat. Nor shall I easily forget the hospitality afforded us in the midst of that primæval forest, or the kindness of the gentlemen summoned from neighbouring mines to bid the foreigners welcome, and the attention shown us during our inspections by day and the merry hours with songs and games in the evenings was the record, stamped on my memory still deeper shortly after on hearing of the sudden death of our host, the manager, through illness intensified, if not actually brought on by his care of his guest. He had deprived himself, unknown to me, of his fur to supply the place of mine—the attendant had sent mine elsewhere—as we ascended from the warm shaft into a temperature of 30 below zero. From the above remarks you may gather that the natural resources of the country are of great value. We should therefore expect the inhabitants, if they had in any measure made use of their advantages to be living in comfort. To those whose idea of a Siberian dwelling is a hut I would recommend an inspection of my photographs in the room adjoining. Wooden houses there are, many preferring them to stone or brick. Church and schools costing from 20 to 50 thousand pounds are presented to towns by merchants and miners who seek an outlet for their wealth. You may hardly credit my statement but I will quote the words of a French writer (M. Meignau). "Lost in wonder at the palace of M. Kumezow (Krakoiarssn) as extensive as our grand Parisian mansions and almost as luxuriously appointed. There are several others almost as grand. The miners of Irkutsh are still more extravagant in their fancies, favoured by their wealth. The most prolific gold mine in all Siberia yields annually £1,200,000; it is the property of three proprietors only. The gold miners of Irkutsh —(the tea merchants of Kiachta)—to finish with these instances of the flaunting of stupendous riches, gratify their passion for exciting envy and wonder of considerable donations to the churches." You may gather that such communities require supplies of various goods to no inconsiderable extent. Therefore, when such goods are carried by sea and no duty is exacted on them we should be able to sell them, giving an advantage to the Siberian merchants and a handsome profit over the costs of the enterprise. I will now describe the present means of communication by which merchandise is transported this immense distance. Goods from France, Germany, England are sent to Moscow by the ordinary routes. Foreign and Russian goods, during the summer months, leaving Moscow, are conveyed by water to Perm, thence formerly by road, now by the recently-constructed railway over the Urals to Tjumen. Over 300,000 tons of merchandise are annually sent into Siberia by this route. At Tjumen they are again transferred to the river system. You will observe that, whilst the general flow of the Siberian rivers is northward, the branches tend east and west. Following the goods down the Tobol and Irtish, we then join and ascend the Obb, and thus carry our goods to Tomsk by water. Thence they are sent eastward in summer over almost impassable wheel-roads, in winter by the cheaper and easier sledge roads to Krasnoiarsk. This river route is the only summer one, and the lowest transit rate is £20 a ton from St. Petersburg to the Yenisei, but, as a rule, far higher rates are paid, and heavy goods such as machinery and boilers, are conveyed with the greatest difficulty. In winter, the rivers being frozen, the only transit over this immense distance is by sledge, consequently the cost is enormously enhanced. The distance from Nishni Novgorod to Krasnoiarsk is 2,500 miles. On our way home by sledge on this route, I calculated we met on an average 800—1,000 freight sledges a day in caravans of 100 to 200, half from the East, laden with tea, half from the West, with sheet iron, machinery, rails, and packages the contents of which were not visible. The Government have just made a canal from Atchiusk to the Yenisei, but I doubt if it is yet practicable, and, being made far too narrow, it is likely to prove a failure. From the Yenisei at Krasnoiarsk, goods go eastward by road to Irkutsk and other towns. The wealthy Siberiakoff has acquired the monopoly of transit on the Augara, on condition of his making it navigable. There are rapids of about ten miles' current. He has laid down in them chain cables sent overland from Newcastle, and has built two powerful steamers with additional appliances for chain-hauling up the rapids. He has besides to spend a large amount in blasting rocks in the rapids. If he succeeds he will have executed a grand work, and one which will be most advantageous to us, opening up by water the Irkutsk district. We have valuable minerals which this summer we had hoped to get floated down in barges from Irkutsk, but this was impracticable. There is a Government scheme for the construction of a railroad, which will probably be the longest in the world. I find the popular idea is that it will damage our sea trade. But I am looking forward to its construction with interest, as I anticipate great advantages from it. It is to start only from Tomsk, passing through Krasnoiarsk, Irkutsh right away to Nicolaivskey. The only loss to us will be the cheapening by £2—£3 a ton of the cost of transit from Tomsk to Krasnoiarsk, 370 miles, and so reducing the selling price of our English merchandise at Krasnoiarsk by this amount. But, on the other hand, it will open to us a better market in Tomsk for our goods sent up the Yenisei, and will enable us to tap a most valuable mineral and agricultural district. Then, again, by the cheapening of the cost of transit eastward of the Yenisei, it will improve the trade both outwards and homewards with this region. A still further work may be carried on up the immense but rapid tribuaries of the main rivers by providing very fast light-draft steamers and launches. There are comparatively few roads in the country. The great main road east and west is the trunk artery, fed by the few minor roads that branch off, but all the rivers are highways, being available for steamers, and barges and boats towed up by convicts, horses, or dogs, also in winter forming splendid sledge-roads, which thus feed the main road. It is generally thought that it must be a terrible drawback for a country to be frozen up five months. But it is the winter that is looked forward to as the cheap and easy time for transport where there is no water communication. Every stream is then bridged, the muddy or baked-lumpy road, over which wheeled traffic is conducted with great difficulty and fatigue to men and horses, is exchanged for a smooth and almost frictionless track, along which you may for the most part gallop in comfort, at least until much traffic has spoilt the road. Produce can be brought from the farms without fear of decomposition for many months. In such a vast country winter brings many blessings with it that we certainly cannot appreciate at a distance. So much for the means of communication. Next as to the attitude of the people and of the Government towards us. On our arrival with the Phœnix, we telegraphed to the British Ambassador at St. Petersburg, asking him to request the Government to grant us freedom from duty on our goods. The Czar was at Copenhagen. A messenger was despatched to him, and he personally signed the decree in our favour, and a fortnight after our arrival the goods were free to be sold. The Governor of the province of Yeniseisk telegraphed congratulations upon our reopening to them the route they feared had been lost. The merchants, at first, were somewhat suspicious, fearing lest we had come, as others had before, to open up a competing retail trade in the country; but, after a time, on my assuring them our desire was only to do a wholesale trade with themselves, supplying them with goods cheaper than they were now getting them overland, they saw their own advantage, and confidence was restored. The miners and manufacturers gladly welcomed us, seeing the advantage they would gain especially by getting improved and heavy machinery by water carriage. The richest gold miner there, who has led the way in the new quartz crushing, said to me, "What you want to make your scheme succeed is co-operation on our side, and I am ready to do what I can to assist you." The only people who are opposed to us are the overland carriers and some Russian manufacturers. But three-fourths of the press of the home country is in our favour saying, "Is the interest of Siberia to be set aside for the benefit of a few fat Moscow merchants?" I myself believe our very opponents will rather gain than lose if we succeed in assisting in the development of the country. As to the Ministers, every assistance has been afforded us by them. They are naturally desirous of developing the latent wealth of this splendid country. They have shown us their goodwill by granting five years freedom from duty on almost all sea-borne imports. For years they have desired to see this route developed. Pessimists shake their heads and say "that is all very well, but what about the end of this period?" My strong belief is that it will be our own fault if their privileges are not then extended. Russia is assisting her people in developing a trade with the East, as we heard from Mr. Curzon. Instead of crying out against a Government for doing their duty, let us do ours. Let our Government do as much as they can, consistently with our economical principles, and let our manufacturers and merchants do their part, and we shall succeed ultimately in every instance except where natural advantages of production and transport are on the side of other nations. My business travels in Europe, as well as in Siberia, have convinced me that English manufacturers and merchants are to blame for much of the difficulty of competing with those of other nations. But I cannot here take up this wide question.

DR. NANSEN'S JOURNEY.

Dr. FRITHJOF NANSEN then read a paper on Greenland to a crowded audience.

The PRESIDENT, in introducing Dr. Nansen to the section, said that the crossing of Greenland was one of the most remarkable achievements that had been accomplished as regarded the present year. It required great energy and courage, and the character of a leader of men. He thought they were fortunate in having Dr. Nansen's presence at that meeting, and they were also honoured by the presence of Mrs. Nansen. (Cheers.) He was glad to see by their applause that they were delighted that Mrs. Nansen was with them. (Cheers.)

Dr. NANSEN then read the following paper :—When I first put forth my plan to cross Greenland, most people said I was either mad or tired of my life. Neither was, however, the case; and, notwithstanding all warnings, more than forty men offered to accompany me. I selected three Norwegians, viz., Captain Sverdrup, Lieut. Dietrichson, and a peasant, Kristian Kristiansen Trana. From Lapland I got two Lapps, Samuel Balto and Ole Ravna, who, I hoped, would in various ways be of use to us, but I was rather disappointed; they were good and strong men, though Norwegians would have done just as well, and in dangerous positions they were easily frightened. On the 17th July we left the ship in the ice near Cape Dan, outside the Sermilik fjord. A salute from the guns of the ship announced to the solemn and silent ice-world surrounding us that we were burning our last bridge leading back to civilisation and comfort. From this moment we had to take our own way. It was with strange feelings that we six men partrd from our friends on board the ship and steered our two boats into this desolate ice-world, which now was going to be our home for a long time. We had, however, all of us the best hope of succeeding; that dangers and hardships were coming we knew, but we felt sure that we would overcome them. The first thing we had to do, and a very important thing indeed, was to reach land. But before we could do this, we had to force our way through an ice-pack of about ten or twelve miles' breadth, and this was one of the most difficult parts of the whole journey. I had originally hoped to penetrate the ice in one or two days, but we met with a quite unexpected strong and dangerous current, which pressed the ice-floes against each other, and where we had to take great care that our boats should not be crushed. To make things more difficult we got for some time fog and rain. I shall not tire you with a description of our drift along the east coast of Greenland : how we dragged our boats over the ice-floes, how we worked hard and tried to force our way towards land, how, in the nights, with those charming Arctic sunsets which call forth in your mind all your most tender feelings and dreams of your childhood, how we then could be seen throwing longing looks towards that wild and beautiful coast whither our only longing was, but from which we were parted only by some few miles of vexing ice. I will not tire you with a description of how often we hoped to land, how often we were disappointed, and how often we were nearly wrecked amongst the ice-floes, which were swept over by the breakers, and when we had very nearly got a last cold bath ; the worst of it was, that the precious summer-time was passing away, and we were not able to use it ; the difficulty of carrying out our plans greater every day. On the 29th of July we landed at Anoritok, which is, however, not very far from the south point of Greenland, and is situated in 61½ deg. N. lat., consequently about 250 miles south of the place where we intended to begin our journey across the continent. It was then very late in the season ; the best time of the short Greenland summer had paased away, and there was but little left. It would have been very easy to reach the Danish settlements on the west coast near Cape Farewell ; northwards the floe-ice was pressed tightly against the coast all the way. We had to choose here between certain rescue in the south and the accomplishment of our plans, or perhaps death in the north. If I had asked my two Lapps I was sure of the answer—it would have been southwards on any conditions; but if I had asked my brave Norwegians I was just as sure that the answer would be northwards—we should not at any risk give up our plans. None of them were, however, asked. Arrived inside the ice, the boats were steered northwards without any order ; there were no thoughts of giving up our plans yet, there still was left time enough to cross Greenland if we used our time well. I will never forget the sensations which possessed us when we passed the last floe that parted us from land ; it was as if we had escaped a long and dreary prison and saw life lying bright and gay before us. And certainly life was bright, but I will not say we had much time to enjoy it ; the order of the day was to sleep as little as posssble, eat as little and as quickly as possible, and to work as much as possible. Our food was water, biscuits, and dried meat ; for cooking we had no time, though there was game enough. The ice was very difficult, we often had to break our way through it by help of axes and poles. It often looked almost hopeless ; it would take us hours to advance some few feet, but we advanced, and that is always better than to go backwards, and I had five brave companions who would not give it up. On the way we met with several encampments of heathen Eskimos living on this desolate coast. I never forget the first meeting with them. It was in a place where I had not expected to meet with any one, that we at once heard voices, and saw a great number of human begins gathered on the shore and gazing at us. We hoped to get some help from them, but they could not advance through the ice so well with their skin boats as we could with our wooden ones, and we were obliged to leave them. At last, on the 10th of August, we reached a place called Umivik, where I thought it convenient to begin our ice journey. After having examined the glaciers in the neighbourhood and found a good way, and after having made everthing ready, we left our two boats on the coast and started on our journey across the unknown interior of Greenland. Our destination was the Danish settlement of Kristianshaab, at Disko Bay. We had five sledges; the load on four of them was about 200 pounds each, and on the fifth about double as much. The last was pulled by Captain Sverdrup and myself, who took the lead, the other four members of the expedition following, each pulling one sledge. Our food consisted principally of dried beef, pemmican, meat-biscuits, dried bread, butter, *pâté de foie gras* (not the Strasburg luxury), meat-chocolate, common chocolate, tea, &c. Besidse provisions, we had on our sledges scientific instruments, guns, Norwegian snowshoes (called *ski*), Canadian snowshoes, Alpine axes and walking-sticks, Alpine ropes, one tent for all six, and two sleeping bags of reindeer skin. As we slept three men in each bag, they were very warm; and we could stand the very low temperatures we had in sleeping on the snow. Notwithstanding the very steep slopes we had to climb, and the many crevasses, &c., we advanced rather rapidly for two days; then we were stopped by a storm from the north, with heavy rain, and we had to stay in our tent lying down in our sleeping-bags for three days, while the ice melted rapidly under us, and the rain poured down above. At first the snow was very uneven, but hard and good for sledge-pulling. There were plenty of dangerous crevasses, so that we had to be vigilant: no accidents happened however. Occasionally some one fell up to the arms through the snow-bridges by which we had to pass over the large crevasses, but by help of the Alpine axes a deeper fall was prevented. At some distance from the coast, however, the snow became very soft and bad for pulling, and our difficulties went on increasing; the snow became looser, and the pulling was very hard work, even if we had not had a continuous snowstorm beating against us. I hoped that it would soon become better, but each day it became worse. It was only too clear that if it continued in this way we would not be able to reach Disko Bay till the middle of September, when the last ship left for Europe. We should thus have no hope of returning home the same year (1888) if we continued our way to Kristianshaab. We should probably have more hope of reaching a ship at Godthaab, situated further to the south, on the west coast of Greenland; and as I thought this direction to be of more scientific interest, I changed our route and turned towards Godthaab, though I expected to find more troublesome ice in this direction, and though it would be much more difficult to reach the Danish settlements for rescue after leaving the inland ice. That was on the 27th of August. We had then reached about 64° 50′ N., about 40 miles from the coast, and a height of about 7,000 feet. By this change of direction the wind became so favourable that we could use sails on the sledges, and thus they became less heavy to pull. In this manner we advanced during three days, then the wind went down, and we were obliged to lower our sails. In the beginning of September we reached a quite flat and extensive plateau, which resembled a frozen ocean. Its height was between 8,000 and 9,000 feet, though towards the north it seemed to be considerably higher. Over this plateau or high land we travelled more than two weeks. The cold was considerable. I am not, however, able to give an exact statement of the temperature, as our thermometers did not go low enough. I believe that on some nights it was between 45° and 50° Centigrade (between 80° and 90° below freezing point, Fahrenheit). In the tent where we (six men) slept, and where we cooked our tea and chocolate, it was even less than 40° Centigrade (72° of frost, Fahrenheit). During one month we found no water. To get drinking water we were obliged to melt snow either in our cooking apparatus or by our own warmth in iron bottles, which were carried inside our clothes on our bosoms. The sunshine on these white snow-fields was bad for the eyes, but no case of snow-blindness occurred. To give a description of the scenery during the day in this region is easy. We saw only three things: that was the snow, sun, and ourselves. One day was quite like another. But still, even this part of the earth has its beauties, and I shall never forget the glorious sunsets and the nights on the snow and ice-fields of Greenland, when the ever-changing northern lights were scintillating perhaps brighter than anywhere else. The landscape was not always, however, so peaceful as here described, sometimes we met snowstorms, and you often saw nothing but drifting snow. One day, the 8th of September, we were even obliged to remain in our tent, whilst it was nearly torn to pieces by the storm; the next day, when we wanted to continue our journey, we found that the tent was almost quite buried in the snow. We had to dig ourselves out through the snow, and we had to hunt for our sledges, which had quite disappeared; that, however, was very often the case in the mornings. As to our daily life in these inhospitable surroundings, with a temperature sometimes of 70° to 90° of frost, Fahr., I shall not tire you with a particular description of that. I shall only say that we stood it pretty well. The worst thing was to turn out in the morning. It sometimes happened that I found my head in the sleeping-bag surrounded by a crust of ice and rime caused by the freezing of my breath. To turn out an hour before the others to cook, and be obliged to touch iron articles and get spirits of wine on your fingers, was not very agreeable. I had this pleasant work every morning, as the others, when they tried it, generally used too much fuel, and we had to be careful in that respect, as we could not get any water without fuel. As to cleanliness, we could not afford to indulge much in that luxury. I am afraid you will consider me a thorough barbarian when I tell you that we did not wash ourselves from the time we left the ship Jason until we reached the west coast, that is, during two months and a half, and during that time we were never out of our clothes. That we did not wash had, however, its peculiar reasons; on the one hand, we had no water; but, on the other hand, even when we had it, washing was strictly forbidden, as the washing of the face is very injurious on snow-fields, where the sun is constantly shining, as the skin is easily blistered, and the sun can cause you dreadful pains. Our cooking was not always of the tidiest character; we had no water to wash our cooking vessel, and when we had cooked pea soup in the night, we had to cook tea or chocolate in the same vessel next morning, with the remains of the pea soup in it. It was, however, rather good, as we could not afford to throw away anything in the nature of food, neither were we very particular about what we got to eat. I remember one night our cooking apparatus was upset, and all our precious pea soup was poured out over the canvas floor of our tent; but we did not hesitate—we immediately took hold of each side of the floor, lifted it up, and sucked the pea soup out of the middle. No drop was lost. We were compelled, in fact, to live live natives. Mashers, I fear, would not succeed in the interior of Greenland. On the 19th September we got a favourable sailing wind, so that we could use sails on our sledges. We had only to stand on our *ski* and hold on to our sledges, while we rattled down the slope towards the west coast, sometimes with a speed quite astonishing. Certainly that was the most delightful *ski* race I ever had in my life. Towards night, when it was getting dark, and as we were travelling at a good speed, I observed a dark spot in front of us. I did not understand what it was, but went straight ahead. At a distance of some few steps further, however, I discovered that it was a broad crevasse; the sledges were immediately turned just at the right moment; we were already on the margin of the crevasse; a second longer and the three of us leading with two sledges would have disappeared, and nothing would have been heard of us any more. We had to be more vigilant after this. When the night came, we would use the favourable wind as long as possible, and, as we got moonlight, we could sail on for a very long time. I ran in front on my *ski* examining the ice, and the sledges came sailing afterwards. We had to pass many crevasses, but no accidents happened. Once, however, a snow-bridge over a very deep and broad crevasse fell down just when we had passed over, and very nearly took with it two men and two sledges. In the middle of the night we were at last stopped by ice so filled with crevasses that we could not advance any longer, and we had to pitch our tent and go to sleep. We were now very near the coast, but met with ice so difficult and uneven, and filled in all directions with immense crevasses, that we could advance only very slowly. At last, on the 24th of September, we reached land at a small lake to the south of Kangersunek, a fjord where a large glacier issues. On the 26th September, we reached the sea at the inner end of the Ameralik fjord, in 64° 12′ N. lat. I shall never forget what pleasure and enjoyment it was to get water again, so that we could drink as we liked—no wine could have tasted better; and what a comfort it was to have any quantity of fuel, willow, and heather, so that we could make an open fire in the night and cook as much as we liked. We had now reached our destination—the west coast of Greenland. The distance we had passed over inland the ice was about 260 miles. The interior of Greenland was explored, at all events in one direction, in spite of the general opinion that it was impossible to penetrate it. We had now only one thing left, and that was to get into communication with other human beings. This it was desirable to do as soon as possible, as we had not very much food left; we had plenty of dried beef, but we suffered from want of fat. But Godthaab, the nearest place where people lived, was still a distance of fifty miles away. As I saw that it would be no easy task to reach this place by land, the mountains being too difficult to pass, I thought it better to go by sea, and determined to make a boat. The next day three of us made a boat out of the canvas which formed the tent floor, of the bamboo rods used on the sledges, and willow boughs found near the shore. Towards night our boat was ready. Next day, September 28th, Captain Sverdrup and I started with this boat for Godthaab. The first portion of the way we had to carry it, as the fjord is filled with glacier mud. This was rather a heavy task, as we often sank into the mud up to our knees. Next day we reached open water and got out of the Ameralik fjord. For some days we got contrary winds, and the boat was very heavy to pull against wind and sea, it being too broad as well as short. Food and water plenty. On the 3rd of October we reached Godthaab, and were heartily welcomed by the population. Two boats were sent to bring the other four members of the expedition to Godthaab. Being stopped by a heavy storm, these boats were, however, obliged to wait for several days. At last, on the 12th of October, they arrived, and all of us were assembled in Godthaab. The expedition was finished, and Greenland was crossed for the first time.

Mr. RUS CARSTENSEN also made some observations on Greenland, and on the motion of Dr. RAE, seconded by the PRESIDENT, a cordial vote of thanks was proposed to Dr. Nansen.

SECTION F.—ECONOMIC SCIENCE AND STATISTICS.

INDUSTRIAL DISPUTES.

The proceedings were opened by the reading of a paper by Mr. L. L. Price, M.A., on "The Relations between Industrial Conciliation and Social Reform". In the course of his paper, Mr. Price said:—"The paper is devoted to some general considerations on the character of the relations existing between the various methods of securing the peaceful settlement of industrial disputes known as (1) arbitration, (2) conciliation, and (3) the sliding scale, and general social reform. The study of social and industrial questions leads to the conclusion that social and industrial reform is dependent on moral reform. But this is often forgotten, and more importance attached to the 'machinery' of reform than to the 'material' of human nature with which reform has to deal. The neglect of the fact that human nature changes slowly, bit by bit, leads to extravagant optimism and excessive pessimism with regard to the methods of securing the peaceful settlement of industrial disputes. We must expect that this "machinery" will sometimes fail, but this expectation has its compensation as well as its drawbacks. A change has taken place in the "material," and theory and practice testify to an improvement in human nature as between masters and men. This is specially illustrated by the positions of trades unions in general opinion and conversation, and also in economic literature. The practical consequences of this are important, for thus alone can effective representation of the men be secured; but the lessons of the recent history of the Northumberland coal trade must not be ignored. Although the "machinery" of industrial peace is not everything, yet it is something, and it may modify the "material" of human nature, and should therefore be brought to as great perfection as is possible. The most desirable quality is adjustability, and this may be understood in different senses: (1) adjustability to the varying circumstances of trade, (2) to the varied circumstances of each particular industry, (3) to those which vary from one industry to another, and (4) to the varying stages of improvement in the relations between masters and men. Future, like past and present, industrial society will probably present manifold diversities, and the ideal attitude of the social reformer should be catholic and critical.

Dr. R. S. WATSON followed with a paper on "The Difficulties of Arbitration." The author referred to the manner in which disputes in the northern iron and coal trades were settled by arbitration and conciliation. The department of conciliation, he said, was the more useful one, but it was the department which had made the least progress. If the peaceful way of settling trade disputes had been practised with success, how was it, he asked, that conciliation was not generally adopted? The first difficulty in the way was the prevalence of caste feeling between employer and employed. This, however, he believed, would die out with the growth of experience and spread of education. He advocated the adoption of boards of arbitration and conciliation in all branches of industry, and spoke in hopeful terms of the ultimate spread of such organisations for the settlement of wages disputes to unskilled labour. From the highest point of view, the interests of the employer and the employed were one and the same. A fair price was a reasonable compensation for the skill and strength exerted and time expended on the article produced, and that price only should be asked and given.

The next paper was one by Mr. Sidney Webb, LL.B., on "The relation between wages and the remainder of the economic product." He said: The scientific determination of the various divisions of the wealth product is primarily a problem, not of distribution, as it has usually been treated, but of classification. The economic product, obviously heterogeneous in its non-economic attributes, is economically homogeneous only in its attribute of valuableness. This aggregate wealth product is open, quite irrespective of its objective distribution, to scientific analysis and classification, based upon essential differences of economic attributes. The actual or potential objective distribution of the product among consumers, the outcome of all the circumstances—historic, industrial, and ethical—of each community, is largely effected by this natural classification, but never wholly coincides with it. In economic wealth classification wage has no more to do with the hiring of labourers, or interest with the borrowing of money, than economic rent with the hiring of land. The main classes of the product are: (1) reproduced capital, and (2) income. Income can be classified into: (*a*) rent of immovable capital; (*b*) rent of moveable capital; (*c*) rent of (scarce) personal ability; and (*d*) wages. The reaction against the wage fund theory has been carried too far. The rejection of the limits of a predetermined fund has often led to the assumption of the potential illimitability of the share of wages within the total of the product. Or wages have been regarded as the residual element in a potentially illimitable total, only the three other classes of income being determinate. More careful definitions of the four classes of income should enable wages to be as strictly determined as the three others. The economic product is universally resultant from a combination of the factors of production, and no part of it can be ascribed to any particular one among those factors. The total varies according to the aggregate effectiveness of the combination of the factors, but the classification of the total according to their relation among themselves. The relation among the factors of production is expressed by their marginal effectiveness. The limit of each income class is determined by (1) the marginal effectiveness of the corresponding factor in production, and (2) the excess of its total over its marginal effectiveness. The marginal effectiveness of land and skill is usually nil, and that of mobile capital is measured by the rate of (loan) interest; but in all these cases the excess of the total over the marginal effectiveness is great: the marginal and the total effectiveness of labour as such are necessarily identical, being the product of labour on the contemporary margin of utilisation of land, capital, and skill. The class wages can accordingly never include any part of the result of the existence of immovable or movable material capital, or (scarce) personal capital, superior in effectiveness to the very worst in use. Its limits (as well as theirs) prevent it trenching on any of the three other classes. With unrestrained individual ownership, in perfect frictionless competition and universal omniscience, the objective distribution would constantly coincide with the subjective classification. Private property in capital, whether immovable or movable, necessarily involves the power to extract as mere "rent" the equivalent of the whole economic advantage of all instruments of production exceeding in effectiveness the worst in use. The remuneration of those human beings who contribute their personal services cannot permanently exceed what they would produce with instruments merely of marginal effectiveness. Abstracting (scarce) personal capital, the ordinary labourer cannot permanently obtain, under individualism, more than his potential individual product at the very margin of utilisation of land, capital, and skill.

Sir B. C. **Browne** opened the discussion on the papers. In what was called the wages question, he said there were two difficult things which they had to watch. One was the improvement of the condition of the workmen, and the other was they must try to keep clear of trade disputes. As to conciliation, his impression was that the amount of tolerance and forebearance which was exercised on the side of the employer, and also on the employed, was incalculable, and did a great amount of good in the world. If they took the disputes on the one hand with the men and the disputes with those from whom the manufactures bought material, they would find that the commercial disputes were much in excess of trade disputes. Whatever they might do in regard to organisation of skilled and unskilled labour, in regard to the latter he hoped they would never lose sight of their old friend emigration.

Mr. T. **Burt**, M.P., said with regard to the change that had come over public opinion as to trades unions during the last twenty-five years, he could certainly bear his testimony to that, because at the beginning of his official experience trades unions were opposed, not only by political economists, but, with few exceptions, by the public press. A trades union leader—the man selected by the men to represent them—was invariably depicted as a fierce demagogue. A great change had taken place, and these unions had vindicated themselves, and, in the opinion of some people, were becoming somewhat too respectable. As one who had always advocated the more conciliatory methods of settling disputes, he could not help feeling a certain amount of disappointment as to what had taken place, especially within recent years. A few years ago he had come to the conclusion that, whatever occurred elsewhere, as regarded the Northumberland coal trade they had seen the end for ever of these industrial conflicts, especially in the shape of strikes and locks out. But only recently they emerged from a strike. While disappointed somewhat, he still said that they had progressed very much. For many years they referred these disputes to arbitration, and they had the encouraging fact that in every case the arbitrator's or umpire's award was accepted and loyally carried out. They never had a pit stopped in resisting any of the awards. (Applause.) As to sliding scales, they were resorted to for a great number of years in their negotiations with the coalowners, in regard both to advances and reductions in wages, as the result of rise or fall in the price of coal. A sliding scale was in operation for a considerable number of years, and during that time he felt perfectly satisfied that a great deal of friction had been avoided. They could not, however, disguise from themselves that sliding scales, especially during recent years, had fallen into considerable disrepute with the workmen; and he believed there was only one surviving sliding scale and that was in South Wales. One of the difficulties arising from the operation of the sliding scale had been its slowness in working, especially in responding when there had been a rise in the price of material. But it was a very significant fact that had the sliding scale—if they took the last in operation for a considerable time in the Northumberland coalfield—been in operation up to the present time, not only would they have avoided a strike of 17 weeks that took place in the Northumberland coal trade, but practically they would have been as nearly as possible at the point they had reached after a considerable fluctuation in price, and after the workmen had had an advance of wages of more than 20 per cent. This would astonish the workmen themselves, because they were under the impression that they had got more than any sliding scale would have given them. Sliding scales were at a discount with Northumberland miners. The notice for the termination of the sliding scale was given by the employers. If the employers could have gone on for a few weeks they would have avoided the disastrous strike that resulted at that time, and everybody would now have been in a better position, so far as the coal trade was concerned. As to caste, they had got over that in the coal trade. There was always an open road towards the employers for the men's representatives. And although for the time being arbitration had failed and the sliding scale had been thrown aside, still the joint committee existed and conciliatory methods prevailed, and year after year a great number of disputes were settled by employers and workmen meeting round a table and discussing matters. (Applause.)

Mr. H. L. **Pattinson** thought for the purpose of settling disputes it was possible to have a State department of arbitration, with permanent officials, and worked on lines of impartiality and fairness.

Mr. J. C. **Laird** had more faith in conciliation than in arbitration.

Mr. **Wigham Richardson** said it would be a step in the right direction from the employers' point of view if a committee in settlement of disputes was as small as possible. And it would also be better if the workmen could give greater powers to their delegates. These difficulties, he thought, would be gradually removed.

Dr. **Watson**, in reply, said the formation of such a department as that referred to had been brought up constantly, and a bill was actually drafted in connexion therewith. In his opinion, it was very much better to have arbitration, which depended simply for sanction on honour than on law. (Applause.)

The section then adjourned for luncheon.

ELEMENTARY SCIENCE TEACHING.

Upon resuming, Dr. **Gladstone** read the report of the committee appointed for the purpose of continuing the inquiries relating to the teaching of science in elementary schools. This year has been one of continued depression in regard to the teaching of science in elementary schools, and of disappointment in regard to legislative action. The return of the Education Department for this year shows again a diminution in the teaching of the science subjects. The statistics of the class subjects for six years show an actual decrease in elementary science, and a comparative decrease in geography. The return of scholars individually examined in the scientific specific subjects shows an actual falling off in every subject except mechanics and chemistry. The rapid and serious decrease of attention paid to these science subjects is shown by the percentage of children who have taken them, as compared with the number of scholars that might have taken these subjects, viz. :—

In 1882-3	29·0 per cent.
,, 1883-4	26·0 ,,
,, 1884-5	22·6 ,,
,, 1885-6	19·9 ,,
,, 1886-7	18·1 ,,
,, 1887-8	16·9 ,,

and it must be remembered that children who have taken two of these subjects count twice over. The Government laid upon the table of the House a new code, which would have had a slightly beneficial effect upon the teaching of science; but it has been entirely withdrawn. The Government has introduced no Technical Instruction Bill this year—except just at the last moment—and that is confined to secondary education. It was hurried through the committee and final stages during the last week of the session. Sir Henry E. Roscoe, however, re-introduced his bill with some modifications, and it passed the second reading at a comparatively early period of the session; but the Government would only give facilities for its progress through the House on the understanding that very serious changes were to be made in it. As he could not accept these, it has not passed the committee stage; and it was ultimately withdrawn. Mr Samuel Smith has again brought in a Continuation Schools Bill; but there has been no opportunity of discussing it since the first reading, and it was therefore withdrawn. The subject has, however, grown in the estimation of the public.

Dr. Cooskey (Birmingham) said boys at school should be taught common instruction in ordinary scientific principles. Legislation should provide for them that training which was nearest their lives, instead of the education which was given at present, and which was almost a disgrace so far as common scientific principles were concerned.

Sir Benjamin Browne said the School Boards would be amazed at the high standard of the qualifications of the lads who came to his firm to be apprenticed engineers. Recently one boy of 13 years of age came to him and he failed to puzzle him with problems from Euclid. His opinion was that whatever could be done voluntarily was better than by Government.

APPRENTICESHIPS.

Sir Benjamin Browne then read a paper "On Apprenticeships in the Engineering and Shipbuilding Industries," as follows :—Taking the trade of an engineer as typical of all the trades employed in engineering and shipbuilding, the writer describes the ordinary training of an apprentice who wishes to be a first-class workman. It is an object for him to be educated cheaply, and to earn some wages as soon as is practicable. Experience shows that apprenticeship generally should be six years, or five at least—preceded by good schooling. To be a good mechanic long training is necessary; and, above all, to know good work from inferior work. A regular course of progress from one class of work to another should be carefully followed so as to teach every class of work up to the most difficult. In this the real interest of the employer is the same as that of the lad—viz., to learn every step thoroughly, and then to pass on to something rather more difficult. 1. Is the training of a manufacturing workshop absolutely necessary, or can any substitute be found? 2. Is such training all that is necessary, or is anything else required to supplement it? The writer contends that a long training in a manufactory is absolutely necessary, but that this certainly ought to be supplemented by theoretical and technical training. Referring to the practice of employers as to the latter, the Elswick Works nearly forty years ago commenced the Elswick Mechanics' Institute, with science classes, for training their apprentices. This was less common than it is now, and the good work done by this institute has been very great. Since then many good classes have been established in Newcastle; and when the firm R. and W. Hawthorn was reconstructed, in 1870, instead of commencing new classes the partners decided to pay the fees of every apprentice who attended any evening class approved by the firm. Besides evening classes, if it were possible, it would probably be a great gain to give a lad six or eight months of theoretical teaching when he was just out of his apprenticeship. In a trade like plumbing there is a great opening for really good scientific teaching to supplement, not to supersede, the ordinary workshop education. This is now supplied in many places. In boiler-making and shipbuilding it has to be borne in mind that a young boy is not physically able to do or learn much at first, so he may, if need be, get another year or so at school; but in this case it is necessary, and the writer believes the union insists that he shall continue his apprenticeship after twenty-one, till he has served a sufficient time—a most wise arrangement. As regards the class known as premium apprentices or pupils, these are young men who can afford to pay to receive exceptional training to enable them to take a higher position at an earlier age than they could do otherwise. To them, as to the others, there is no substitute for the manufactory as the proper place of education; but they may advantageously spend one or two years at college or at a technical school before or after apprenticeship. In this class no rule can be laid down, and every lad's case must be taken on its merits—with a view to his position and future prospects. To conclude. The old-fashioned system of apprenticeship, not much shortened, and with very slight modifications, is the only reliable method for either employer or mechanic to learn their business; but as work has become more scientific and elaborate, it is absolutely necessary for any young man who wishes in any degree to excel that he should have a good theoretical and technical training in addition to his factory experience. The college workshop is, I believe, the least useful part of a college, and often does more harm than good. I believe many of our most scientific engineers would like them shut up altogether. It all comes to this; a trade, as a whole, must be taught by those who have learned it and are practising it. We wish the engineer of the future to be a scientific man, and for this we need the services of the professor, but a lifetime spent in a university will never make a man an engineer. I think universities have done much harm by giving degrees in engineering. If such are given at all, they should be bestowed exclusively and solely by engineers. No one can admit into a trade or guild of which he himself is not a member, and it is very wrong to pretend to do so. The engineer of to-day, whether mechanic or master, is a far more scientific and skilful man than his predecessor in the last generation. His training must be more expensive, tedious, and varied, but we may fairly hope that his rewards and remuneration will also be greater. It is most important that the engineer and professor should each clearly understand his own position and duties in the training of youth, and co-operate cordially in bringing about the best result.

The Secretary (Mr. L. L. Price) read a letter from Principal Garnett, of the Durham College of Science, bearing on the subject. In that letter Professor Garnett said he practically agreed with all Sir Benjamin Browne's paper—which he had seen—except the last paragraph. As to the last paragraph of Sir Benjamin's paper, he did not think it fairly represented the position of the universities in this matter.

TECHNICAL EDUCATION.

A paper was next submitted by Dr. Rutherford (Newcastle) on "Technical Education," in which he said :—The forces contributing to the decline of apprenticeship, mainly those tending to the specialisation of labour and the massing of workers in large factories. Specialisation of function involves the loss of versatility. On grounds of mere economy we must cultivate man's higher nature. In olden time the apprentice had more varied work, and by close personal contact with his master felt the influence of his character and skill. Impossible to resist the economic law, which leads to the subdivision of labour: the question is how to secure for young beginners in the workshop the best possible training. The duties of employers, of foremen, and of learners themselves to do each their part in the work. Kindly personal leading the great want, for which no amount of educational machinery can compensate. The first duty of the nation to broaden, to liberalise, and to perfect the common school education. Greater elasticity should be given to it. Boys and girls have to use their bodies as machines. They should, therefore, have some knowledge of the nature, construction, food, and work of those machines, and of the conditions under which their highest power can be most economically developed. The manual exercises of the infant school should be continued through all the standards. With the subjects of needlework, cookery, drawing, and modelling in clay added to these, the girls will find enough for the training of the eye and the hand. To these may be added joiner-work for the boys in the sixth standard; though it is an open question whether joiner-work should be commenced till the sixth standard is passed. Till then no special preparation should be attempted for any particular trade. No employer of labour, except under exceptional circumstances, should engage a child who has not passed the sixth standard of an elementary school, or an equivalent examination. There should be no half-timers, except those who under a medical certificate are declared incapable of bearing the strain of four or five hours' school work per day. The things lying at the foundation of a sound system of technical education are these:—(1) The inheritance by our children of a strong physical constitution; (2) an improved physical education at school; (3) a longer stay at the common school; (4) an improved general education; (5) a higher moral training; (6) thorough instruction in the honourableness of manual labour, and in the duty and advantage of a busy, active, industrious life. Under an improved system of primary education. an increasing number of children would be able, and would be induced to go forward to the secondary school. The physical and manual exercises of the elementary school should be continued and increased by laboratory work. Beyond that point it is doubtful whether they should be increased until the education of the perceptive and reasoning faculties is further advanced. For occupations requiring special intelligence and skill mental discipline comes first in order of time and importance. Nor is it much less so in those occupations where human labour is reduced to the monotonous drudgery of a machine. The course of instruction in science and art laid down in the "Science and Art Directory" would, with certain liberal modifications, mark the next stage in a curriculum of national technical education. Remodelled and liberalised, the Science and Art Department might give us a system of secondary schools well adapted to the wants of the country. No attempt should be made to ignore, far less to starve or suppress voluntary effort. Where that fails or is inadequate, it should be the duty of some public body, preferably one elected for the purpose, to make the necessary provision. For the co-ordination of public educational work in the various localities, educational councils should be formed, with a proportionate representation of the different schools. The Science and Art Department should be largely staffed by men who are practical educationists. The responsible head of the department should be advised by a council of men who have have had experience in the management of the largest and most successful schools in the kingdom. The system of payment by results should either be abandoned, or it should be applied to all the institutions receiving Parliamentary grants, not excluding those under the immediate management of the department itself. Higher grants, if the system is continued, should be given for passes in the advanced and honours stages. These grants should be somewhat proportioned to the labour and cost expended to attain them. Payment should be made for passes in all the subjects of a year taken by a student, so that the courses of instruction recommended by the department are followed. Practical mechanics should, in the "Science and Art Directory," be placed in the same relationship to theoretical mechanics that practical chemistry and metallurgy do to theory in those subjects. The regulations regarding schools of art, which press so unduly and so severely upon industrial as compared with middle-class students, should be modified so as to prevent the industrial student from being handicapped in the national competition. The only guarantee that the department should require as to works is that they have been executed by the student under the direction of the teacher. To enable committees and teachers to learn from their failures, the examination papers, when the department have done with them, should be returned to the respective schools and classes from which they were sent up. With such reforms, and the addition of commercial and general subjects to the syllabus, a system of secondary public schools might be established well fitted to prepare for a true,sound technical education. Strictly speaking, that education can only be said to begin when the scientific principles on which the trade rests have been mastered, and when there is sufficient knowledge of art to enable the apprentice to read drawings with accuracy and facility. To reach that standard a course of three years' instruction will be required, and when that time cannot be given in the secondary day school it should be completed by attendance at the evening classes. It is at this point that the apprentice should begin to specialise and apply his studies. He should also seek rapidly to acquire the manual dexterity and manipulative skill that will enable him to do his work well and quickly. In many trades that dexterity and skill can only be acquired in the actual workshop, the stimulus to rapidity of execution only there being found in sufficient force. There are, however, trades which, though they cannot be well learnt except in the workshop, have tools the nature and uses of which can profitably be taught in technical schools or colleges. It is along these lines that we, at Bath Lane, have been endeavouring to advance. Our experience confirms the views expressed by Mr. Mather in his report on the position of the United States to the Royal Commissioners on Technical Education. He does not attribute the superiority of the American people in many branches of industry to the nature of their technical instruction, but to the high character of their common schools. The light thrown by our statistics at Bath Lane on those points. The mediœval corporation was known as a university, even though it was composed wholly of smiths or coopers or tailors. In the reign of Elizabeth it was enacted that no person should exercise any trade or mystery without having served a seven years' apprenticeship. By the judges that statute was held as applying only to the trades then existing. All the new industries, such as those of Manchester and Birmingham, were thus exempt. Eventually, through the influence of the teachings of Adam Smith and the political economists in 1814, the statute of Elizabeth was wholly repealed. But we might escape the danger, monopoly, and exclusiveness without throwing away the advantages of thorough training. The trades' unions have, to some extent, taken the place of the ancient guilds, and it is for them to consider whether they would not confer a benefit upon their class and upon the country by requiring a certain term of apprenticeship, or some evidence of capacity for work from their members.

The foregoing paper was followed by one by Mr. EDWARD J. WATHERSTON, London, on "Manual or some form of Technical Instruction, a necessary element of a compulsory system of Education," which began by pointing out that, while school accommodation in England and Wales new exists for all the children who should be filling the seats, viz., 5,300,000, the number on the school registers only amounted to 4,700,000, and the average attendance in 1888 was only 3,630,000. This lamentable state of things existed in spite of the School Boards and school attendance committees, and of a costly central department, and the fact that the annual expenditure on elementary schools exceeded £7,000,000 sterling. His contention was that the instruction actually given in the schools was mechanical, lifeless, and uneducating, and his great point was that the remedy for the defective teaching and the bad attendance would be found in a system of manual and technical instruction, which would re-act on the ordinary subjects of education, and help to make the scholars more skilful and scientific handicraftsmen when they go into the world to earn their livelihood at the forge, the factory, the chemical works. or the loom. "Give the children an education that will be valuable to them," says Mr. Watherston, "and we shall not be deploring the bad attendance at school. Why do not our workmen and foremen possess a sound knowledge of the science on which their industries depend?" The reply is simple. Our system needs complete reform. But it needs more than that. Not merely must we adopt the large-hearted and intelligent methods of our continental neighbours in assessing the quality of the education given in our schools; we must remember they are our rivals as well as our friends, and it behoves us immediately to learn what they are doing in the direction of industrial teaching. Our present system dwarfs the intelligence of children, it inspires them with no delight in knowledge, it does not humanise them. Finally, it does nothing to help them to be skilled artisans or handicraftsmen. It throws them into the world at the age of twelve or thirteen with a mass of dry, undigested, and barren facts —hand and eye left untrained—to pick up by rule of thumb practical knowledge enough by which to earn a living.

Discussion ensued on the three papers.

Mr. **Boden** (Gateshead) said some regard must be paid to the practicability of things. He could answer all the questions asked him in the affirmative. They were asked if they were cultivating the intelligence of the children of the country. They were doing so. The reason why children were not taught science was because they did not stay long enough at school. Another reason might be given by the fact that there was no possibility of finding teaching power. Considering everything, he thought they might congratulate themselves on the progress that had been made. The Government inspectors did not encourage the teaching of specific subjects in elementary schools.

The Rev. **Theophilus Bennett** said every one who knew the educational system so thoroughly as a clergyman, must see that it has many defects. A great deficiency was at Whitehall. He had been nearly hanged by the red tapeism at Whitehall. If they wanted a place where they did not know how to do a thing, he would refer them to the Educational Department. He fully endorsed what had been said about the pedantry at Whitehall. He should like to see reform in our schools, and particularly in the system of cramming. If it came to a question of voluntary or board schools, and he had fifty votes, he would give the whole for board schools. (Laughter.)

Mr. **Wright** (Gateshead) said they had already a crowded curriculum in the schools, and science teaching was crowded out. Manual work had been retarded by giving it fine sounding names such as technical knowledge. He quite agreed that to have anything like technical education in schools was an absurdity. But when that had been said he did not say the last had been heard of handicrafts. If the teaching of drawing and that kind of thing could be shown to be a good thing a point had been gained. In his school he introduced mechanical drawing, and the mere drawing of pieces of machinery had exercised such an influence on his pupils that applications for clerkships had ceased and every lad aimed to become an engineer. He could not agree with the remarks in the papers about the supremacy of the Continental schools, and he spoke from experience in regard to French and Belgian schools.

Mr. W. **Botly** said that at the last meeting of the British Association he said that education, if it were to be national, must be undenominational, and that opinion he still held. The greatest error in all education had been that it was too denominational.

Mr. **John Philipson** said he was one who believed in the true working apprenticeship, and in teaching every youth to use his hands, and not only that, but his brains as well. That was the way technical education would come. In the first instance a youth must not be more than 15 or 16 years of age, if he had to follow one of the manufacturing industries of the country. He advocated the rising generation recreative schools to draw them in and encourage them in education after their 15th or 16th years. As to the science of applied mechanics, that was a matter that could be taught in night schools, and in the Newcastle College of Science there was every facility for such teaching, If the Government wished to encourage education, it would be a good thing to give £500 more yearly to be spent on prizes. If by doing this they were encouraging the intelligence, in developing the inventive genius which might be in the youths of future generations, the money might be well spent.

Mr. **Stephen Bourne** thought the system of education should be directed more to explaining to the youngest children the nature and the value of the work to be performed hereafter, and so encourage in them a taste for using their hands and powers. He believed the real fault was not so much in the education department or teachers as in the parents and pupils. There was a sad want of feeling amongst the labouring population of the value which was to be attached to education, and a want also of parents encouraging a desire in their children to avail themselves of the advantages which were given them. Children were taught to read, and then for amusement they were given to read the most pernicious literature printed, and allowed to go to music halls and such places. They should rather be given amusement in the exercise of their hands and the putting forth of their knowledge.

Sir Benjamin Browne and Dr. Rutherford briefly replied on the discussion.

SECTION G.—MECHANICAL SCIENCE.

DISTRIBUTION OF ELECTRICITY.

Major-General **Webber**, of London, read a paper on the Distribution of Electricity in Chelsea, with accumulators as the main source of supply. He said: Accumulation of electricity is a first necessity for the effectual distribution of electric light from a centre of generation in a densely inhabited area, and all candid-minded people admit its advantages. Electric lighting has made progress as an industry in spite of the half-hearted support it has received, and that progress has not been due to the superiority of the systems employed, but to the accident of one or other having been taken up by one or two believers in the future of the particular system they had backed. Chelsea, in which work, under a provisonal order confirmed by Act of Parliament, has been first undertaken is an average town district, the only exceptional advantages it possesses being that it is partly in the course of being rebuilt. The proposals made for distributing electricity in it in 1884 and 1886 and those that have been carried out in 1888-9 are nearly identical. But capital declines to show faith in those proposals at first, while in the cheaper system with aerial lines a good deal of money has been in the meantime invested. The Chelsea system may be described in the following terms:—Accumulation of the main supply from a generating station in storage stations, situated at suitable distances from one to another, combined with the following: — (a.) Charging the accumulators at high pressure, and discharging them for distribution at low pressure, and effecting the changes necessary to the same by special automatic arrangements placed in each storage station. (b.) Supplementing the main supply by means of continuous current motor transformers. (c.) Distributing by means of mains laid down in a net work. (d.) Maintaining a constant pressure by means of the introduction into the discharge circuit of counter E.M.F. cells, and by means of feeding joints judiciously placed intermediate between the storage stations. (e.) The use of underground conductors throughout, laid so that the cables can be drawn in and out, and renewed or repaired whenever necessary without disturbing the ground. The cost and inconvenience of wiring houses is one of the impediments to the spread of electric lightning. There are, besides, several other unfavourable conditions. For instance, the risks from bad work by inexperienced persons; electric light wiring requires careful specification and skilled supervision. The Board of Trade rules and fire insurance rules are very restrictive. But, in spite of hampering restrictions, the burthens of rather arbitrary rules, &c., by which gas and water distributions are not hampered, the apostles of electricity believe they will and must succeed in the end. The metres used in Chelsea—are the

"Aron," the "Chamberlain and Hookham," and the "Brush" metre. There are inconveniences connected with the installation of transformers in buildings which need precautions in connexion with the same. The author described the system of laying the mains, and gave an account of experiments made in 1884 and 1886, resulting in what was known as the Callender-Webber system of underground electric mains. The fundamental advantage of the system was the power which it gave for drawing in and out of the conductors when their insulation required repair or renewal. Each storage station supplied current to 2,000 10-candle-power glow-lamps on ordinary occasions, and 2,500 in an emergency. These figures, by a moderate further outlay, could be increased by 50 per cent. The possible ultimate demand no one could estimate. One might make the statement that every dwelling must take the electric light, and that it was easy to doubt any scheme which did not now provide for such an end. But, from actual experience, it was clear to him that the question was still very obscure, and that the end was still far off. It was claimed for the system that the cost of generating and plant did not exceed that of any other system. It was also claimed that the cost of the mains was less than that of any other system, and that the working cost was less than that of many other systems.

The President said the committee thought it would be convenient if the first three papers were read, and the discussion upon them taken together.

THE ELECTRIC LIGHT AND FIRES.

Mr. W. Killingworth Hedges, of London, read a paper on "Precautions to be Adopted when the Electric Light is Supplied by means of Transformers." He said: In a paper entitled the "Fire Risks of Electric Lighting," which was read at the meeting of the British Association held in Southport in 1883, I brought forward for the first time the necessity of electric light regulations and the use of safety appliances. The fire insurance companies have almost universally recognised that the electric light can only be considered a safe illuminant, when the strictest attention is paid to the details of an installation; and the regulations which have been published by the principal companies and by the Institution of Electrical Engineers have so far proved successful, as no fire of magnitude can be traced to the electric light. The introduction of transformers has led to the increase of the electro-motive force in the primary mains, and there appears to be a tendency to decrease the pressure in the secondary, consequently there is an enormous difference of potential between the two systems and a constant strain on the insulation of the transformer. A transformer may be compared to the reducing valve which converts high pressure steam into the safe pressure for working heating coils. There is, however, this difference—a transformer never sticks like a valve, but it sometimes leaks, and the consequences are similar to those arising from a leaky reducing valve. Supposing a small leak to take place between the primary and secondary coils; it is quite possible that a small current of dangerously high potential might be introduced into the secondary circuit, which would make very little difference to the light from the lamps, but might cause fatal results on any one inadvertently touching some unprotected portion of the wires or fittings with one hand and a gas pipe with the other. To produce this effect it is necessary that some earth should occur on the primary main or mains. With the overhead wires which have almost universally been employed, with alternating currents of high E.M.F., any leakage to earth may be avoided, but with an underground system, and with the increased pressure which is about to be introduced, there is sure to be some earth connexion; in fact, with the Ferranti system, one of the conductors is to be earthed throughout. Allowing that a possible danger exists, the question is to find a safe preventive, and with this object it is proposed to briefly recapitulate what has been done. Mr. Kent inserts a metallic shield between the primary and secondary coils of the transformer; this sheet of metal is connected to earth. Now, if the insulation of the primary coil should fail, the leak before reaching the secondary coil must pass through the sheet of metal and thus to earth, causing the primary cut-out to melt and thus cutting out the faulty transformer. The next plan is still simpler, and is to earth the secondary circuit, so that the effect of a contact in the transformer would be to establish connexion through the earth and to blow out the primary fuse as in the previous method. It has been stated by several high authorities that this arrangement is all that is wanted to secure perfect safety against shock, but the question of fire risks has also to be considered, and these would be greatly increased, also the insulation of the wires in houses would have to be of the most expensive character. Allowing that every care had been taken with the insulation, the proximity of gas and water pipes in a house to the wires, which are often laid under floors, might open a path for the deviation of a leakage current, say of 2,000 volts or over, and an arc once formed would result in a dangerous fire. The fire insurance offices have not sanctioned this plan, which does not even appear to be used in those go-a-head institutions, the electric light companies of the United States, who apparently employ no safeguards, and trust to Providence with regard to the "burn out" of a transformer, having a ready supply of duplicate parts to at once replace in the faulty instrument. We now come to the intermittent earth device, that is the automatic apparatus which only comes into play when the potential in the secondary has dangerously increased. Dr. Fleming has described an instrument which consists of a fine-wire safety catch holding down suitable contact pieces in mercury cups against the pressure of a spring. The safety catch would be arranged to stand the normal difference of potential between the two secondary mains, but as soon as that rose beyond a certain amount the circuit would be automatically broken. This plan has the disadvantage of a certain amount of loss of current, which would be, however, checked by a resistance; but it avoids the necessity of using an earth. Dr. Bernstein advocates his contact plug, which contains a substance, the resistance of which can be made enormous with the normal current, but the heating effect of an increasing current causes the mixture in the plug to be decomposed, and a metallic circuit established. I am unaware whether this has been tried in a circuit from a transformer or not, but am afraid it would not answer in practice. Major Cardew, whose improved apparatus I have the pleasure of showing you to-day, has, so far, produced the most successful device. It has been called the static mouse-trap, in that it goes off directly an unauthorised volt enters it. The arrangement which you see on the table takes the form of a box; in it there are two brass discs, separated one from the other by an insulating washer of ebonite. Between the two discs is placed a small strip of aluminium foil which lies in ordinary on the lower disc, which is connected to earth. The other disc is in connexion with the secondary coil of the transformer, and should any leakage take place from the primary so as to raise the potential in the secondary say by fifty per cent., that part of the aluminium foil which is under a projection on the upper disc will be attracted to it, making an electrical connexion and starting an arc which short circuits the secondary and causes the primary fuses of the transformer to be melted. Working quite distinctly from Major Cardew, I have also designed a safety appliance, which may be called a "vacuum cut-out." It is on the lines of those lightning protectors which are often used with telegraph cables, but the electrodes are fixed at each end, and cause the current on its way to earth, after leaping across the points, to energise an electro magnet which releases a short circuiting device connected with the primary poles of the transformer. There is one great advantage in my vacuum cut-out, in that it is not effected by dust or moisture, which might impede the static arrangement. In practice, I propose using old incandescent lamps, with their broken filaments sprung, as they often are, one-sixteenth apart. The perfect vacuum must, however, be destroyed, or only high potential will pass, and the current will preferably short circuit across the terminals, instead of leaping across the broken filament. A lamp of this description would cost very little, and could be fixed in the same manner as the Cardew cut-out, without any relay. Numerous experiments were made to ascertain the distance which an alternating current would leap across points in tubes exhausted to a certain amount. The results differed considerably from the figures given by De la Rue in his experiments with continuous currents. In one experiment with glass cylinders having conductors hermetically sealed in opposite ends, and with a pressure of 5m/m., less than that equal to a perfect vacuum, an alternating current of 1,000 volts invariably passed between the ends of the copper electrodes, which were ·3 inches apart. The arc, however, did not remain steadily at the ends, but would first run down one electrode to the point where it was connected to the platinum wire, which came through the glass, with the result of fusing it away. The arc would at the same time extend almost to the glass, although the opposite electrode was left intact. The reason for this phenomenon with an alternating current may be perhaps explained in the discussion. In conclusion, I think that all those who intend using high tension alternating currents, for the supply of electric light and power, should be obliged to fix a safety device on the secondary circuit, near the transformer, with the object of not only protecting their own property, but also to do away with the possibility of an unauthorised current being inadvertently led into a building so as to endanger the lives of the public.

THE DESIGN OF TRANSFORMERS.

Mr. J. Swinburne read a paper on "The Design of Transformers."

DISCUSSION.

Professor George Forbes (London) said General Webber's paper was one of the most important papers they had had on the subject of the distribution of electricity. It was not a hypothetical paper; he dealt with what had actually been done by his company, and it was the first large scale of application of storage batteries of this size and in this way, and everyone must see, from the description given in the paper, that every part of the scheme had been thought out with a care which had been by no means common in all the central stations, which had been designed on a new plan for the first time. (Applause.)

Mr. Powell said he was rather surprised to hear what Mr. Hedges had said about the introduction of electric light into houses, particularly in face of the remark made by Mr. Preece in that section last week—that there was almost absolute immunity from danger to individuals—that the dangers were more of a mechanical than of an electrical nature. He was under the impression that they were almost absolutely free from danger from fire.

Mr. W. H. Preece, Chief Electrician to the General Post Office, London, said an immense amount of interest was felt in the system described by General Webber, of electricity by accumulators in Chelsea, particularly as the first attempt made at Colchester some years, ago, was a failure; but, secondly, because there was most remarkable and strange want of confidence in accumulators. Those who used accumulators had very great confidence in them. (Applause.) He had been a staunch advocate of accumulators since their introduction into this country. Mr. Hedges was guilty of a terrible heresy when he spoke of the relative advantages of underground wires and overground wires. He spoke on the insulation of the underground system as far inferior to that of the overground system. As a matter of fact, the reverse was the case. The underground system not only gave a very much higher insulation, but it did very much more — it gave a uniform insulation. As to the danger from electricity, when he spoke the other day, he referred solely to dangers to persons, and to-day they had heard more about dangers from fire. It was often said, "Have the electric light in your house, and you will be absolutely safe from any fear of your house being burned down." That was a very great mistake. There was not the slightest doubt about it that there was as much danger nearly—not quite—of fire by introducing the electric light as there was from introducing gas. The chief danger arose from the use of imperfect material, and especially from the employment of inexperienced men—(applause)—also from the want of just those very contrivances which Mr. Killingworth Hedges had brought before them. If good material was used, if experienced men were employed to lay down the wires, and if all the apparatus of safety such as they had heard from Mr. Hedges be admitted, then electric light was absolutely safe. As regarded dangers to a person, that was quite a different thing. He alluded the other day to a strange remark made by Mr. Stephenson. One of the reasons he adduced against the use of the distribution of power by means of electricity was that, if a man touched a wire, he would be killed. That was absolutely, in scientific language, rot. (Laughter and applause.) The State of New York recently passed an Act makingexecution in future execution by electricity. They had not yet rescinded that Act, but they would be obliged to do so, because they could not get sufficient power to kill a man with certainty. He remembered on one occasion making some experiments with an enormous induction coil, and they tried, with a spark about 20 inches long, to kill a rabbit, and they could not. (Laughter and applause.) They wanted to try on him (Mr. Preece), but he was not quite ready to offer his body, while other animals could be found. But there were many of them who had taken immense shocks. Colonel Armstrong, at Chatham, took shocks that were supposed to kill individuals, but he was very well after it, and indeed looked all the better for it, and felt inclined to try again. The result of experience was that electricity, with proper precaution, was without danger to person, and all that was said about it was chiefly nonsense. Newspaper correspondents very often got up sensational paragraphs. There was a case at Brighton only three weeks ago, in which it was alleged that a man had been killed by a shock from a wire. The Board of Trade sent down Major Cardew to investigate, and he found that the electric current had been turned off two hours before the man was killed. (Laughter and applause.)

ELECTRIC LAUNCHES.

Professor G. Forbes read a paper on "Electric Launches on the Thames." He said he had not the slightest doubt that in the course of a very few years the steam launch, as used to-day on the Thames, would be entirely abolished. The result would be inevitably the survival of the fittest, and the electric launch would take the place of the steam launch. The electric launch was free from the objections of smoke and oil, and was much better fitted for the comparatively small speed allowed on the Thames by reason of the traffic. There should be a sufficient number of charging stations on the river; and he had found that the charge in the accumulators was certainly not exhausted in forty hours. Taking the size and accommodation into consideration, the electric launch was cheaper than the steam launch.

ELECTRIC TRAMWAYS.

Mr. Edward Manville read a paper on "Series Electrical Traction (Northfleet Tramways)." He said the expenses of horsing a tramway form such a serious proportion of the total working expenses that any cheaper effective method of propulsion will naturally be gladly received by the various companies. Many leading authorities in tramway administration who have tested and considered the various methods of tramcar propulsion have of late publicly expressed their confidence in the great suitability and economy of electricity for the purpose. It is obvious that, in any systems of mechanical traction requiring the distribution of power over many miles of line, the maximum economy is attained when all the power is developed at one station. The economical distribution of electrical power over long distances necessarily involves the use of current at high potential, though at the same time it is dangerous to permit large differences of potential at the terminals of motors running in parallel, both in respect of manipulation and the preservation of the motors from injury; but if the motors are run in series these difficulties disappear, and the advantages of high potential are secured. The extension of the Gravesend, Rosherville, and Northfleet tramways, equipped upon the Series system, was opened in March last. The salient points of a Series electrical tramway are a dynamo, producing a current of constant quantity—a closed metallic circuit of which travelling motors at all times form a part without ever being short-circuited, or having the current supply cut off from them—the regulation of the power developed by the motor and absorbed by it without interrupting the continuity of the circuit. The "Statter" dynamo, used at Northfleet, varies the difference of potential at its terminals from a few volts to upwards of 400, maintaining the current constantly at 50 ampères. This is achieved by an ingeniously-designed electrical regulator, which alters the position of the brushes on the commutator; the pole-pieces of the dynamo being so shaped as to reduce to a negligable quantity the sparking which might be supposed to result from the alteration of the lead of the brushes. A highly-insulated cable connected to one terminal of the generator traverses the whole length of the line, and is interrupted at distances of 20 feet, the divided ends being connected with opposite faces of a "spring jack," which is at the same time the automatic switch and contact point. From the last "spring jack" at the far end of the line an uninterrupted cable returns to the other terminal of the generator. The "spring jack" consists of two gun metal "cheeks" attached to glazed earthware blocks by spiral springs, which keep them in contact. The "arrow," or current collector, which is the same length as and is carried by the car, is so constructed as to pass between the faces of the "spring jack" and conduct the current to the motor without at any time short-circuiting it or interrupting the main circuit. The motors at Northfleet run at 400 revolutions per minute, delivering a maximum of 15 horse power on the brake, a pinion on the motor shaft gearing direct with a spur wheel on the car shaft, with a ratio of 1 to 4½. A car is lighted electrically by low-resistance Bernstein lamps, running off the terminals of three accumulator cells arranged directly in series with the main circuit. The generator is driven by a compound Robey engine of 10 horse power (nominal), the steam being supplied from a locomotive multitubular boiler. The points and crossings are specially constructed to enable them to withstand the weight of the ordinary traffic, a special device supporting the long unsupported projection of the tongue over the conduit, at the same time allowing the mechanical connexions between the "arrow" and the car to pass. The narrowness of a portion of the road required the construction of a length of double-single line—that is to say, with three rails, so that, while keeping the tramcars on the proper side of the road in the direction they are travelling, it makes it impossible for two tramcars to pass each other in this narrow path. In series-running, by the employment of a current of constant value it is impossible for the most inexperienced car-driver to damage his motor by either too rapid starting or by reversing whilst running. Indeed, it is a positive advantage in descending a hill to check the speed of the car by altering the field connexions so that the armature tends to revolve in the opposite direction to that in which the car is travelling, as the power that would otherwise be lost in braking the car is actually added to that produced by the generator. This, in large systems with many cars and varying gradients would appreciably reduce the total power required to be generated, and the consequent consumption of coal. These advantages, combined with the efficiency of distribution as regards the percentage of power lost in the conductors, with, at the same time, a low difference of potential at the terminals of each individual motor, may be regarded as the main advantages of series-running.

Mr. MANVILLE, in answer to a question, said there were at present in America about 350 miles of tramway worked by electricity. A line upon the series system was about to be opened at St. Louis, which was about 26 miles long, and to have 116 cars running upon it.

TELEPHONES FROM LONDON TO PARIS.

Mr. W. H. PREECE gave an interesting address upon telephonic communication between London and Paris. He said the question of telephonic communication between London and Paris had very much occupied the attention of electricians in Paris, as well as in London. A desire to establish this communication had arisen with the Minister of Posts and Telegraphs in Paris. They had devoted a great deal of attention to it, and it had occupied his time considerably lately, and he thought he could not do better than bring the subject before that section. The distance between London and Paris was 275 miles. It was made up by 74 miles from London to Dover, 21 miles from Dover to Calais, and 180 from Calais to Paris. The mere act of speaking by telephone over a distance of 275 miles was really practically nothing. Distance in telephonic matters scarcely entered into the question at all. If they had a wire, or two wires, from the earth to the moon, they would probably be able to speak to the inhabitants of the moon, if there were any there. The difficulty was one that arose from the character of the materials used, and for the presence either of underground wires or submarine cables. It happened that between London and Paris they had to deal with the difficulties of underground work in London and Paris, and the fact that they had half way nearly across the Channel a submarine cable. In America, they had spoken from New York to Chicago, a distance of nearly 900 miles. When he was in the States in 1884, he spoke between New York and Boston, a distance of 350 miles, and at present in the United States there were many places over 300 miles apart between which commercial telephony was carried on. He had recently been in Paris to look into this question. In Paris they had established a telephonic communication, commercially and practically, between Paris and Brussels, a distance of 190 miles; and anybody could go into the silence box in the Bourse at Paris and he could make an arrangement with his friend at Brussels to go into a similar box, and they could talk together for three minutes or three years. As a matter of fact, it was the success of the Paris and Brussels telephone that had excited the question as between London and Paris. Again, he spoke between Paris and Lille, a distance of 158 miles; between Paris and Havre, a distance of 135 miles; but the longest distance, and the most interesting experiment was when he spoke between Paris and Marseilles, a distance of 600 miles, and he had not the least difficulty whatever in carrying on conversation with the gentleman in the box at Marseilles. In these cases they had not difficulties like those which were met with between London and Paris. The only length of underground wire was in Paris, where it amounted to about two miles. But between London and Paris they had the underground system of London, they had several lengths through tunnels in the country, and they had the 21 miles of cable to surmount. There were certainly difficulties in the way, but they had succeeded in finding out what these difficulties were; and when, in electrical matters, they once knew what their difficulties were, the remedy was very simple indeed. As regarded cables, he had experimented not only between Dover and Calais, but between Dublin and Holyhead and between South Wales and Wexford. These two latter cables measured 60 miles, and he had certainly been able to speak. In this district—here in Newcastle, and its neighbourhood—the wires were almost entirely underground. The telephonic system in Newcastle he believed to be the most perfect in the world. (Applause.) He visited the telephonic exchanges in America and on the Continent, and he did not think there was anywhere a system that worked with such regularity and with such rapidity, and was manipulated so well as this telephonic system in Newcastle, which had grown up under the fostering care of Mr. Arthur Heavyside, whom he saw in the room. (Applause.) Here they grappled the question at once by putting the wires underground. In London and other places the tendency had been to keep them overground, and people had always asserted that it was impossible to work telephones underground. They found it was possible. It was possible to work them under the sea, to a certain distance, and they knew the distance exactly, and they knew why, and could tell what to do. The only things they had to surmount were two electric quantities. One was the capacity of the circuit, the power that it had of storing up electricity. After the current went in, a certain amount of it was stored up, as it were, and did not appear at the other end. The other quantity was the resistance which the wire offered to the passage of the current through it. When the product of the current and the resistance amounted to 15,000, speech was impossible; if to 12,500, speech was possible; if 10,000, good; if 7,500, very good; if 5,000, excellent; and if 2,500 or under, perfect. So that they had a scale by means of which, they could tell at once, given any circuit, between any distances, whether speech was good or impossible, or whatever it might be. They found that, taking the ordinary conductors between London and Paris, using copper wires to the shore in each case, that they would get a product which would be about 12,500. To verify that, he had an artificial line made exactly on these conditions, with a portion representing the wire from London to Dover, another portion the cable, and the third portion the wires in France. The result was that speech, with a product of 12,500, was fair. But it was a very difficult thing to satisfy the unscientific mind with an artificial wire or a laboratory experiment. It fortunately happened that they had coming into London copper wires from various directions, and throughout London there was an underground system of telephones, and, by making a circuit from Worcester through London to Baldock, on the Great Northern line, he was able to reproduce the actual line that represented exactly these conditions that he mentioned as being those likely to be met with by using standard wires between London and Paris. The result was that they spoke with great ease, and no question whatever was left that communication between London and Paris was perfectly practicable and perfectly feasible.

PURIFICATION OF SEWAGE BY ELECTROLYSIS.

Mr. W. **Webster** read a paper on "The Purification of Sewage and Water contaminated with Organic Matter by Electrolysis." The paper was divided into four sections, bearing on the different values of the methods for the oxidation of organic matter in solution, leading up to the action produced by the electric current:—1. By natural processes due to the action of atmospheric oxygen dissolved in water. 2. By the action of the soil, due to oxygen in its pores, and also to the iron oxides therein acting as purveyors of oxygen. 3. By artificial disinfectants, represented by chemicals such as chromic acid, permanganates, chlorine, &c., chlorine having a powerful oxydising action uponall organic matter, living or dead. 4. The electric current produced by mechanical or chemical power. The fact that water and the salts contained therein are easily decomposed, provided the current of electricity is of sufficient intensity, as an explanation of the whole system. The changes taking place in sewage when electrolysed depend chiefly on the splitting up into their constituent parts of sodium, magnesium, and other chlorides, nascent oxygen and chlorine being set free at the positive, and the bases at the negative pole. (*a*) The adaptation of the electric current to filters and filter beds in such a manner that putrefaction cannot take place in the pores of the filtering media owing to the constant presence of nascent oxydising agents, the filter always remaining clean, because the impurities are consumed as fast as they present themselves, all harmful organisms being destroyed. (*b*) The production of disinfectants for household purposes. (*c*) The application of the electric current to plates of oxydisable and non-oxydisable material, fixed in such manner that sewage passing between them not only receives a precipitating agent, but the putrifying organic matter in solution is oxydised to any extent that may be required, the action being produced by metallic oxychlorides, nascent oxygen and chlorine, thus combining in one process the results obtained by both precipitation and irrigation, the intensity of the current not of necessity exceeding two volts, the action entirely depending on the quantity of the current employed. The oxydisable plates are by preference (for various reasons) of iron. It is contended that the process follows more nearly natural action than any other hitherto suggested.

SECTION H.—ANTHROPOLOGY.

ANTHROPOMETRIC LABORATORY.

Dr. J. G. **Garson** also submitted reports of the Anthropometric Laboratory Committee, which stated that during the Bath meeting of the British Association the committee made a number of observations. Experience showed that it was desirable to make slight alterations in the card of observations of the previous year on account of some of the observations requiring more time than it was possible to give them, and a much larger staff of assistants than could be obtained. Mr. Francis Galton very kindly placed at the disposal of the committee most of the instruments required. The characterists examined were as follows:—The sitting heights, standing height, span of arms, length of the fore-arms from the elbow to tip of middle finger, the length and breadth of the head, of the face and nose, the breathing capacity, the strength of squeeze, weight, the colour sense, the judgment of the eye; note was also made of the colour of the hair, of eyes, sex, age, birthplace, and occupation of each individual examined. In all the experiments made, Dr. Garson said, the system of percentiles which Mr. Gordon used in the South Kensington Museum was employed. The system was an extremely useful one, and extremely useful for calculating large numbers of figures. In fact, it saved a great deal of trouble, and it was a wonder to him that it had not been more adopted. He ventured to think that the cause of this had been because in most of Mr. Gordon's publications he had not given diagrams showing the actual method by which these percentiles had been obtained. The places the association visited materially affected the class af persons who were examined—that was to say that in Somerset they met Somersetshire people, and in Lancashire, Lancashire people. The previous researches of committees of the association had shown that in Somersetshire the stature of the people was much less than in Lancashire. That was borne out by the results which they had got in the laboratory. Of course there was a great mixture of people from all provinces, but the fact of the majority being Somersetshire people had undoubtedly had an influence. It would be extremely interesting to find what the result of the present year's laboratory was. If the researches of the previous committees were confirmed, in the north, they should expect that the stature would be somewhat higher. Professor Garson then quoted a number of statistics obtained in the laboratory at Bath. It was rather curious, he said, that they never came across a person pulling with the same strength in both arms. Sometimes they found the left arm stronger, but in the majority of cases the right arm was the stronger of the two.

Dr. Garson then exhibited a new anthropometric instrument specially designed for the use of travellers.

MEASURING SIGHT AND SOUND SIGNALS.

Mr. **Francis Galton**, F.R.S., exhibited an instrument for measuring the reaction time to sight and sound signals, and explained that they heard much about the quickness of hand and eye. When anyone saw or heard a thing he made a movement, and between the sight and the movement many physiological processes took place so quickly that the flash of lightning was nothing to it. The instrument he exhibited was intended to make an accurate measurement of the time which elapsed between the seeing or hearing of anything and the time occupied in making a certain movement afterwards.—Two gentlemen in the audience tested the instrument, and it was found that from the times of hearing sounds and stopping a pendulum it took them respectively 19 hundredths and 22 hundredths of a second.—Dr. Wilberforce Smith suggested that the instrument might be used to test fatigue in school children.

THE SMITHSONIAN INSTITUTION OF AMERICA.

Dr. **Thomas Wilson** discoursed on "The Smithsonian Institution in the U. S. of America, and its Work Relating to Anthropology." He said James Smithson was an Englishman, born in England, the illegitimate son of one of the noble and powerful families of England. Whatever there might be of truth—and they were bound to presume it to be true—in the theory announced by their worthy President in his lecture or address on "Heredity," delivered before that section, it would appear certain that whatever intellectual ability or nobleness of soul, integrity of purpose, and independence of spirit that they might suppose belonged to a noble family of the proud realm of England, was inherited by this man. He was brought up to manhood in ignorance of his lineage. He demanded, when he arrived at manhood, recognition at the hands of his father. He sought the intervention of the courts in some kind of way and was defeated. He became to a certain extent, if not embittered, at least a recluse, and accepted the decision of the court—that he was no man's son, nobody's son. He took the name, equivalent to that, of Smithson—(laughter)—and as such lived and died, and his name had gone down to posterity, probably better known than if he had succeeded in obtaining what he contended to be his true rights. He was a student of one of the English universities, and his library they in America possessed. He went to Genoa, where he made his will, in which he bequeathed to his half-brothers sisters a fair competence, by which they could be kept in that condition of life in which they had heretofore lived, and the bulk of his property, amounting to about half-a-million of dollars, he bequeathed to the United States of America to found an institution to be called the Smithsonian Institution—for the diffusion of knowledge among men. The Hon. Richard Rush was sent by the United States Government to receive the legacy. There was the usual contest over a testament of that kind, but it was declared by the English courts that it was a good and valid bequest. The money was paid, and the United States Government received it into its vaults. They established a corporation, which, while it was not entirely public, was not entirely private. How well that trust had been performed rested with them and with others like them to determine—it was not for him to speak. Prof. Jos. Henry was the first secretary, and was known to the world as having been the inventor and discoverer of the electric telegraph, but he yielded that honour to Prof. Morris. After giving details of the work of the institution and its various sections, he concluded his remarks by saying that while in the United States of America there might be many things that were worthy of commendation at the hands of that association, and he felt proud of them, he desired to say, also, that there were many things in connexion with that association and anthropologists of Great Britain from which they could derive great benefit, and they recognised that the French and English were far ahead of them on the subject of "heredity." He had to take those papers, those specimens, and that machinery to show them to his people and say, "Are you willing that you should rest quietly in the background in regard to those things, while the English and French are going on ahead?" He was glad to say that whatever there might be of commendation about the Smithsonian Institution and America, he could cheerfully, faithfully, and truthfully reciprocate very largely to the British and French Governments. Sir Wm. Turner, Sir Henry Acland, K.C.B., and Professor Evans offered a few remarks on the close of the address.

THE STUDY OF ETHNOLOGY IN INDIA.

Mr H. H. **Risley** next read a paper on "The Study of Ethnology in India." The paper commenced by explaining the special conditions, social and administrative, which made India a readily accessible and peculiarly instructive field for ethnological and more especially for anthropological researches. It went on to describe the measures adopted during the last four years under the sanction of the Government of Bengal for a general ethnographic survey of the population (70 millions) of that province, and for a special anthropometric inquiry into the physical characteristics of the people of Bengal, the North-Western Provinces, Oudh and the Punjab. In the course of the anthropometric survey measurements were taken on the system prescribed by Dr. Paul Topinard, of Paris, and approved by Professor Flower, C.B., F.R.S., President of the British Association, of 6,000 persons representing 89 different tribes and castes. Some of the main conclusions which these inquiries indicate were then stated. It was shown that the population of Northern India comprised three distinct types, viz. :—I. A leptorhine dolichocephalic type of tall stature, fair complexion, and high facial angle, apparently corresponding in all points except hair and complexion with the Aryan type as defined by Herr Karl Penka, of Vienna. II. A platyrhine dolichocephalic type of low stature, black or very dark complexion and low facial angle. The wider racial affinities of this type are uncertain, and it is tentatively and conjecturally described as Australioid. III. A mesorhine, platyopic, brachycephalic type of low stature, yellowish complexion, and low facial angle, described, in virtue of its low naso-malar index, as Mongoloid. The types thus worked out by anthropometric methods were shown to correspond with certain ethnographic groupings independently ascertained. Thus the leptorhine group have exogamous sub-divisions of the sponymous type; the platyrhine group have their exogamy on the totem ; while the brachycephalic group make use of a system of personal nicknames for this purpose. In the Aryan and Australioid types the social status of each caste or tribe is found to vary inversely as its nasal index ; tribes with the highest index having the lowest social rank, and *vice versa*. In the brachycephalic group social status appears to vary with the cephalic index. An attempt was made to deduce from these data a theory of the probable origin of caste, and also to account for the custom of exogamy by the operation of the law of natural selection. The concluding part of the paper discusses the practical bearing of ethnology upon certain administrative and social questions in India, such as famine relief, the management of the excise revenue, the relations of landlord and tenant, the prohibition of widow marriage, the continual extension and perversion of the disastrous custom of infant marriage, and lastly upon the remarkable movement known as the National Congress, the main feature of which was the demand by natives who have received an English education for the extension of representative institutions to India.

THE TORRES STRAITS ISLANDERS.

Professor A. C. **Haddon**, M.A., M.R.I.A., read a paper "On some Former Customs and Beliefs of the Torres Straits Islanders." The author stated : The natives of Torres Straits are divided into two distinct tribes—the Eastern tribe, which inhabits Uga, Erub, and the Murray Islands ; and the Western tribe, which occupies all the remaining islands. There are four subdivisions of the latter tribe, the members of each of which inhabit certain groups of islands. Independently of the above-mentioned subdivisions the islanders were divided into clans, each clan having some animal for its totem, such as the dugong, turtle, dog, cassowary, snake, shark, &c. With the exception of the two first no man was allowed to kill the totem of his own clan. If he did his fellow-clansmen would probably kill him. On a dugong expedition no dugong man might keep the first dugong he captured, but he might partake of all the rest. The same applied to the turtle clan. The women used to have a representation of their totem cut on the small of the back. In the Western tribe the lads on entering into manhood underwent a month's isolation in the bush, during which time they were covered over with a mat, were coated with charcoal, and were not allowed, on pain of death, to see any woman or even their own fathers. Neither were they allowed to talk or play. A relative attended them during that period and taught them the costumes and system of morality of the tribe. This was followed by a grand feast, when the lad was presented to his relations gaily ornamented, and thenceforth he took standing as a man. In the Eastern tribe two elaborate ceremonies attended the initiation of the lads, but the discipline does not appear to have been so severe as in the other tribe. It was the custom in the Western tribe for the women to ask the men in marriage. This was attended with certain recognised formalities. The usual money value for a wife was a canoe, or a dugong spear, or a shell armlet. On the other hand, in the Eastern tribe the men proposed to the women, and the women had to undergo a period of partial seclusion previous to marriage. The eating of food together was a feature in marriage. The funeral customs of the Western tribe appear to have been elaborate. The first operations culminated in the preparation and decoration of the skull of the deceased. The second stage was characterised by handing over the skull to the nearest relatives, the occasion being celebrated by remarkable dances, in which it was a matter of great importance that the women should not recognise the disguised dancers. There were three persons engaged in the main dance, the central one being a man dressed up as a woman. The spirit of the deceased was supposed to go to a mythical island, Kibu, in the west. The Eastern people made their dead into dessicated mummies, which they kept in their houses. Funeral dances were also held. The departed spirits went to Boigu, an island in the west. Belief in sorcery was universal, and all sickness and death were attributed to the charms of the medicine-man. There were also rain and wind-makers. There was considerable trade between New Guinea (Daudai) and the islands, and also intra-insular, Canoes were frequently bought on the three-year-hire system. Most of the stars are grouped into constellations, about many of which myths have sprung up. Legends are also attached to numerous prominent rocks and stones. There are several stories about culture-heroes. All of these narratives date from before intercourse with white men.

CUSTOMS OF NEW GUINEA NATIVES.

Professor Haddon supplemented his paper with some anthropological notes collected by Mr. Edward Beardmore at Mowat Daudai, New Guinea. The writer said: The Mowat tribe is divided into different clans, each having its own totem, the animal being held sacred and the flesh not partaken of by the members of that clan. A representation of the totem is not cut on any part of either men or women, but the latter have some mark made to denote the clan. They have not the custom of a man changing his name at any time or for any reason whatever. The coast-women wear a band of grass from the waist downwards between the thighs, and fastened again to band on stomach. Bushwomen wear grass petticoats from the hips to a little above the knees. Coast men wear anything or nothing. Bushmen wear a band of rattan cane round the waist, with leaves suspended behind. No ceremonies are observed at birth. The mother is neither secluded nor regarded as unclean, nor does she observe any rules as to diet nor have to undergo any ceremony before being readmitted to society. The *couvade* is not practised. The child is named by the father with one name only, according to his fancy, without any regard to his tribe or family. There is no ceremony like baptism, nor any godparents. There are no special observances in regard to infants whose elder brothers or sisters have died previously. Children are not killed at birth. The children do not take the name of either parents' clan or tribe, but they belong to the father's tribe. In the case of twins the mother's brother adopts one child, but without any ceremony. On the lad's arriving at puberty a feast is held, and the lad's health drunk in an intoxicating liquor (komata) obtained from a plant grown locally. There are no rites at which a boy is supposed to be killed, nor are the lads forbidden to see women for a certain time. The only practice is that the youths remain in the men's house for two days to deck themselves with a view to attract the favourable notice of the women. The seclusion is not, so far as I can learn, compulsory, but more from vanity, and to consider how the best effect can be produced. During babyhood the ear-lobes and nasal septum are bored and distended from time to time as the child is growing. I cannot ascertain any reason further than it is a custom handed down. It prevails amongst all the tribes. There appears to be no restriction as to marriage within or without the same tribe or clan. Polygamy, but not polyandry is practised. Their reason for this custon is that the women do the principal part of the work in procuring vegetable or fish food. Marriage is arranged by the respective parents when the children are growing up or are in infancy and by exchange, thus:—If a man has sisters and no brother he can exchange a sister for a wife, but in the case of both brothers and sisters in a family the eldest brother exchanges the eldest sister, and the brothers, as they are old enough, share equally, but if the numbers are unequal the eldest takes the preference. It sometimes happens that a man has no sister and he cannot obtain a wife. Sometimes a wife is obtained by purchase. It may also happen that a woman will have the man of her choice in spite of all laws to the contrary. The wife goes to the husband's house. The chief of Mowat has several wives in his house at one village, with whom he sleeps and spends part of the day, and also at the other village, with whom he spends the remainder of the day when not hunting or gardening. (N.B.—Mowat is composed of two contiguous villages.) There are no particular customs practised during the night before marriage. At marriage a fight takes place between the friends of the man on the one side, and those of the woman on the other, but it ends without injury to any one. The couple usually spend a week by themselves away from the village after the fight. Men do not exchange wives. A widow becomes the wife of the deceased husband's brother. A man may not look at nor speak to his mother-in-law. Murder is sometimes avenged by the relations of the murdered person, but they are not bound to do so. No instance is known of a man committing murder amongst the people of his own village or of a neighbouring village. No compensation is paid for homicide. A murderer is not regarded as unclean. Any small patch of land becomes the property of the person only during cultivation. When a man dies, the property is equally divided amongst the children, but the girls retain their share only until marriage, when the eldest brother takes possession. The youngest child never takes precedence. Fire is obtained by the friction of wood; there are no ceremonies or superstitions connected with it. Eguon, described as a large bat, is fabled to have introduced fire to Mowat. A legend goes that a tribe once inhabited Double Island (near Nagi), one of whose members showed fire to come from the left hand, between the thumb and forefinger, whereupon dissension arose, and the people were all transformed into animals, birds, reptiles, fish (including dugong and turtle). Eguon found his way to Mowat; the others to different places in the Straits and New Guinea. There appears to have been some friendly arrangement amongst the snakes, whereby some took to the land and others to the water. Everything is eaten without regard to persons or occasions, except the flesh of the porpoise. The porpoise is no more sacred than anything else, souls of the departed having it as a totem enter into it only in the same way as souls of others go into other animals. I was positively assured there was no reason for abstaining from porpoise flesh. Men, women, and children eat together. Food is eaten anyhow as to position, often whilst walking about. Cannibalism is not practised. The blood of animals is used after being cooked; the sight of blood is never avoided. They never fast. There is no form of government, but there is one chief to each tribe. The chieftainhip is hereditary if the eldest son is old enough to rule, otherwise it is elective. There are no religious or political associations, and sacrifices are never offered.

NATURAL COLOUR OF THE SKIN OF ORIENTAL RACES.

In the absence of Dr. Beddoe, F.R.S., a paper by him was read by Dr. J. G. Garson (sec.) on "Observations on the Natural Colour of the Skin in certain Oriental Races." The author stated :—A voyage round the world, in 1885, afforded me an opportunity of making a few observations on the colour of the skin in some tropical races. These observations were taken for the most part on the clothed body, so as to obtain the natural colour unaffected by sunshine. I usually selected the outer part of the upper arm, but when this part was unavailable. some covered portion of the chest : very frequently both arm and chest were inspected, when if any difference appeared, the mean between the two was noted. After quoting statistics relating to the standard of colour, the writer went on to say :—Examination of the tables brings out strongly the prevalence of reddish hues in most of the peoples observed, but especially in the Pacific islanders, of whatever race. (I regret having made no exact notes on the Somati, many of whom I saw at Aden. They are the reddest of men, and reproduce in modern times the ancient Pūn or Pount, and the conventional Egyptian male of the old paintings.) The Chinese are an exception : in them yellow preponderates, and grey is common, but pale reddish hues are far from being otherwise. The variation among the Chinese is considerable; of 12, 2 were to my eye purely pale red (21 and 26-32), 3 purely yellow, 2 orange, and 5 of sundry mixed hues, into which grey entered more or less. The Tokien people are easily distinguished from other South Chinamen ; at least so easily that, having seen one, I was able to diagnose the next that I met with as though the one was pale-yellow and the other light grey (23-52 and 24.) Both had features almost European, with well-formed aquiline noses. It will be observed that in respect of colour the Chinese and the Australians are mutually exclusive ; with all the other races examined, the former have at least one point of contact, according to my second table. Still, the correspondence is not exact except in two cases among the Oriental series : it is only the New Guinea men and the Maoris, both of the Malay group, who reproduce exactly a colour, type or combination found in the Chinese, viz., 21 of Broea. There is really more likeness in this respect between the Chinese and Europeans than is generally supposed. An Amoy man and a Macao man, who professed to be of pure Chinese blood, and showed no other indication of European admixture, yielded me Nos. 24 and 24-25, the only ones by which I could designate my Englishmen. And at a scouring-pool, wherein a number of Englishmen and Chinamen were working together bare-legged, it was difficult and sometimes impossible to distinguish the darker Europeans from the fairer Chinese by the colour of the legs alone. I lay no stress on this point as showing the presence of an Asian element in the Chinese, though some may do so, and the fact is pretty certain on other grounds. There is a great difference in the degree to which skins tan or blacken from exposure, and errors are often committed as to the natural colour of races in consequence of this fact. Thus my Melanesians (from Fiji, New Caledonia, Maranoa, and an unknown island) were naturally of a lightish red or orange colour, decidedly lighter, on the whole, than the Australians, or even the New Hebrideans. But they burn almost black, much darker than either of the races with whom I have compared them. Their natural colour is identical with that of the darker among the Maoris, as might be expected, perhaps, from the Maori pedigree. The New Hebrides people are darker than those of Eastern New Guinea and the neighbouring islands. They seem to vary in the several islands a good deal, but on the whole are almost as dark as the Australians, with a little more of the red element. Here again, it is by no means the darkest individuals who turn to the blackest hue by exposure. Mr. Guppy gives 42, 35, and 28 as the prevailing colours in the Solomon islanders. I suppose his men were naked. These numbers are those of the clothed Australians. I am told that the darkest of the Pacific islanders are the people of the Eddystone group, and that they are "blue-black," but this last statement I do not believe. My two series of Maories, one of adult males, the other of children, were gotten at the ill-fated village of Wairoa, near Lake Tarawcra, a few months before the catastrophe which destroyed it. The subjects were all of the Arawa tribe. There may have been a European cross in some of the subjects, but I took no observations where I had any suspicion, and indeed the Arawa, having scarcely any white people living among them, are of purer breed than some other tribes. The Singhalose, who were observed in Queensland, came out less red than I should have expected. One of them, whose chest and arms marked 28, had a face of an almost sooty blackness. The depth of tint, the burnt-in colours of the Gujerati Lascars and of the so-called Portuguese of Goa, may be compared to the natural colours of the New Guinea men and New Hebrideans ; but they are less red in tone, and some of the Goancse have a distinct yellow or olive element, which may be a legacy from their boasted European ancestors, some small portion of whose blood they still retain. The depth of colour to which Europeans, even Englishmen, may attain under free exposure to a tropical sun is not perhaps generally known. North Queensland is a fairly healthy country for Europeans ; the air is clear and dry, and the sun is extremely powerful, but exposure to it is not shunned as it is in most hot countries. The young men on whom I made my observations were fair samples of their race—one, indeed, a colonial by birth, was "blond ardent" by nature; but they were all accustomed to expose their arms freely to the sun. The result may be seen in my tables. On the whole, my Englishmen were tanned to very nearly the same points as my Chinamen, and two out of three became darker than my fairest Gujerati.

NORMAL TEMPERATURE OF THE SOUDANESE.

An abstract of a paper by R. W. Felkin, M.D., on "The Normal Temperature of the Soudanese, Negroes, and Europeans in Tropical Africa," was, in the absence of the author, read by Mr. G. W. Bloxam, M.A, (secretary), as follows :—Observations made in 1878-81 apparently showed that the normal temperature of Soudanese, negroes, and Europeans varied from the usually accepted normal temperature of 98°·6 F. After detailing the observations, the writer stated his conclusions as follows :—The normal temperature of Europeans who had resided in tropical Africa between Khartoum and the equator for over four years was 99°·1 F. ; the normal temperature of Europeans in the same region, none of whom had been more than two years in Africa, 99°·5 F.; the normal temperature of Soudanese (Arabs), 99° F ; that of negroes living between the equator and 10° N. lat., and on the east coast of tropical Africa, average of 600 observations, 97°·8 F. All the observations were made two hours after eating, the individual at rest in the shade, with the thermometer in the axilla.

DIFFERENCES OF SENSIBILITY BETWEEN EUROPEANS AND NEGROES.

A second paper by Mr. R. W. Felkin was read on "Differences of Sensibility between Europeans and Negroes, and the Effect of Education in Increasing the Sensibility of Negroes." The author said : It is very generally supposed that negroes feel pain to a less degree than Europeans. De Quatrefages says in "Human Species," that "general sensibility and the consequent aptitude for feeling pain are very unequally developed." He continues—"The same surgical operation will not cause so much pain to a Chinese as to a European." I have no experience of the general sensibility of the Chinese, but I am certain that these remarks apply in a very marked degree to most, if not all, of the negroes with whom I have come in contact. In 1878, when I first performed operations in Africa, I was much struck by the indifference with which the natives underwent the ordeal. Operations, for which one would certainly have given an anæsthetic in Europe, were performed with comparatively little discomfort in Africa. I must in the first place divide the people with whom I came in contact into two classes ; the first being the so-called Arabs or the people inhabiting the Soudan deserts ; the second, the negro population to the south of the deserts. Now, although the first class underwent operations with extreme fortitude, yet that fortitude appeared to me to be a disregard of pain induced by custom and training, and due also to peculiar mental characteristics, which one may express by the terms self-control, self-repression, or dogged endurance. With this class, however, for the present I have nothing to do. Turning then to the negroes, although I found this same apparent callous endurance of pain, I was led by the observations I am about to describe to you, to the opinion that their general sensibility is far less than that of Europeans, and that they do not feel an operation so acutely as the latter. The skin of an African native is exactly the same as that pourtrayed in all the text-books, the only difference being that there is a layer of pigment contained in the deeper cells of the rete-mucosum. It is possible, however, that the exposure of the body and the application of unguents may to some extent blunt the sensibility of the African skin. This I do not believe, for its sensibility bears the same ratio to the sensibility of Europeans as the susceptibility of the mucous membranes and tongue do, and these of course would be uninfluenced by such exposure. It may perhaps be well to mention here that temperature affects the excitability of nerves. If the temperature is raised, the excitability is increased, and the acuteness of the sense of touch is also said to depend very largely on cutaneous circulation, which is of course very much influenced by external temperature. This being the case, one might, I think, allowably expect that the sense of touch in the African negro should be more acute than that of Europeans, but this may be driving a point a little too far. It seems to me that one is justified in saying that the sense-touch, or general susceptibility of the negroes, is distinctly less than that of Europeans, and I think I am justified in drawing the conclusion that they would therefore naturally feel pain less than would Europeans. I also found that the delicacy of the sense of temperature coincided in the main with that of touch, and that the negroes could not distinguish as well as Europeans variations in the temperature of water. They rarely distinguished a less difference than 15deg. F. Again, their estimation of weights was very faulty. I have often seen a porter insist upon carrying a load 8lbs. or 10lbs. heavier than another, simply because it was smaller, and I rarely found a native capable of appreciating a less difference in weight than 5lbs. Sir E. B. Lytton said: "We live longer than our forefathers, but we suffer more from a thousand artificial anxieties and cares; they fatigued only the muscles; we exhaust the firm strength of the nerves." I cannot help thinking that the high intellectual state to which we have arrived has induced an acutely sensitive state, to which is added of necessity keen sensibility. The negroes on the other hand correspond to our forefathers; the brain is less highly developed, muscular strength is far greater, and the keenness of mental and physical sensation is therefore necessarily far below our own. I should not be surprised, if a series of observations were made upon educated negroes, were it found that their sensibility bore a near relation to that of the average European.

PLANTS IN THE STRUGGLE FOR EXISTENCE.

LECTURE BY MR. W. GARDINER.

In connexion with the meeting of the British Association, a lecture was delivered at night, in St. George's Hall, by Mr. Walter Gardiner, on the subject, "How plants maintain themselves in the struggle for existence." Dr. Flower, president of the association, was in the chair, and there was a very large audience, including all the principal members of the association.

The PRESIDENT, in introducing the lecturer, said he was connected with the University of Cambridge as a teacher of botany, and was universally recognised as one of the most able of the young school of botanists, who devoted themselves to the physcological work of the study of the life history of plants, and he was going to give them a lecture which he believed would prove extremely interesting.

Mr. GARDINER, who was received with applause, said some time ago he received from his friend the secretary of that association a note stating that he was much interested in the subject of the lecture, and informing him that he had been observing in his own garden a plant growing through a trousers button. (Laughter.) He hastened to inform him that, so far as he knew, plants had never adopted, and probably would not adopt, clothes, but would remain in the position which they usually associated with primitive man. (Laughter.) Ordinary English scenery was so full of quiet and so suggestive of repose that one might not readily discover signs of a struggle for existence. In tropical scenery these signs were so clear that they had been recognised again and again by every thinking naturalist who had ever visited tropical regions. Any comprehensive view of the phenomenon of life upon the globe clearly pointed to the one conclusion, that all nature was in a perpetual state of desperate warfare, and the key-note of this address must be: the utter remorselessness of nature, the care for self, and the absolute disregard for others. In all cases the weakest went to the wall. The lecturer then dealt with the evidences of the struggle for existence in the plant world. He took for his first example the *Ficus parasitica*. The seed dropped by birds germinated on the fork of some tree, for example, the Jack fruit—(*Artocarpus integrifolia*). It sent a long root into the soil, gradually spread itself over, and suffocated the unfortunate foster-mother. Then in the case of the *Bertholletia excelsa*, Brazil nuts were contained in each fruit, the fruit being indehiscent. All seeds germinated at once. The most vigorous got first through a small hole at the top to the open air, and strangled and fed upon all the rest. What did plants struggle for? Plants struggled for two main objects, viz., their own nutrition, and the reproduction of their species by means of offspring, which they left behind them, and for which they made adequate provision. The two master functions, nutrition and reproduction, often stood out clearly marked the one from the other, *e.g.*, in the Talipot palm *(Corypha umbraculifera)* where the period of leaf-bearing was succeeded by the period of fruiting, the latter being accompanied by the final death of the whole plant. Speaking of nutrition, he said protective adaptations in plants were associated with the mainly nutritive organs. Large forest trees had buttressed trunks, the *Canarium commune* for example, while the large leaves in palms were often tied at the leaf lease. Young buds of many tropical plants hung vertically downwards so as to expose the least surface to the sun, as in the case of *Amherstia nobilis*. Prickles were also a common means of protection, the immense leaf of the *Victoria regia* being protected from fish, &c., which, in rising from below, might rupture the leaf-tissue. Some plants provided ants with home, honey, and food. The *Ipomœa paniculata* attracted ants by racemose glands supplied with definite ducts, two of which were present in each leaf, at the junction of blade and stalk. During the unfolding and growth of the bud, special mechanisms existed. Thus water-glands occurred at the apex of each leaf tooth, which provided for the escape of the superabundant water sucked up by the root, otherwise the delicate leaf tissue might be ruptured. In fully developed leaves on a cold night drops might be seen escaping from the teeth. Other glands were also found which secreted mucilage or resin and so protected the young structures from the effects of excessive drought, e.g. ferns (*Blechnum Braziliense*) and other plants (*Clusia* and *Coprosma*). The next point to be noted was reproduction. The importance of this process was sufficiently obvious from the enormous expenditure of material and energy plants lavished upon it. *Hodgsonia heteroclita*, an extraordinary Indian climber, with its complicated structure and great beauty, opened for one night only, and shrivelled up and fell off the next day. *Amorphophallus Titanum*, with its huge inflorescence (the largest in the world), although it took months to develop, opened only on one night, and then only for a few hours. One of the contrivances to ensure fertilisation was shown in the *Masdevallia muscosa*, an orchid, which had a sensitive labellum, and an insect alighting on it and touching a certain part was shot into the flower and held a prisoner for some time. *Cuphea silenoides* was protected from the attacks of insects by very numerous hairs secreting a gum-resin. Many insects were caught, and as many as 7,280 might be counted on one plant. Then there were plants protected by ants, although the flower was fertilised by some other insect. *Plumbago rosea* had nectaries on the leaves and flower bracts which attracted ants, but the ants were prevented by sticky hairs on the calyx from obtaining access to the honey in the flower. Some plants depended upon the enormous quantity of seeds produced, *e.g.*, the wild carrot (*Daucus carota*), which moreover sowed its seeds by instalments and at different times. Others, *e.g.*, *Voandzeia subterranea*, sacrificed the advantages obtained from a wide dispersal, and depended upon the formation of a few seeds suitably placed in the soil. This plant in fact had a mechanism for itself, sowing its own seeds beneath the soil. For purposes of distribution *Uncinia brevicaulis* had its fruit provided with small hooks. Small birds, unable to pull out the seed, were occasionally caught and killed in Jamaica. *Stipa pennata*, a grass, bored its way into the ground and was even liable to bore its way into the bodies of sheep who were so unfortunate as to come in its neighbourhood. Contrivances for assisting plants to maintain themselves in the struggle for existence were by no means limited to the higher plants. They existed also in the fungi and the algae, even in the smallest and most microscopic of them. For example, among the fungi there was *Clathrus triscapus*, a Queensland fungus, which had an orange-red colour, and the spores smelt strongly and were embedded in a sweet mucilage. Colour, scent, and sweetness, were the usual advertisements used by the higher plants in connexion with pollen dispersion. The mildew of the alder had wonderfully hooked fruits which were possibly carried about by tiny *Acari*. Spores were shot out with some force from the mycelial filaments of the fungus which attacked and killed flies. The ergot, *Claviceps purpurea*, at the time of spore formation, secreted a sugary nectar so that flies were attracted, and ate and disseminated the spores, just as birds did stone fruits. The spores of *Sclerotinia Vaccinii* had an almond smell, were gathered by bees with the pollen, and being placed on the stigma of healthy flowers, infected the ovary and prevented the formation of seed. In the race between the pollen grain tube (the rightful owner) and the fungus-spore mycelial-tube, the fungus always won and soon spread itself throughout the tissue of the entire ovary, producing more spores for the bees to gather in mistake again. In the algae, the resting spores of Desmids—a microscopically small green algae—were frequently covered by a spiny silicious coat. These probably prevented them from being eaten by *Amœbæ*, rhizopods, &c. The protoplasm of certain cells of *Oedogonium ciliatum* (a fresh-water filamentous alga) were in the habit of escaping from the cell wall and beginning life anew. This production of the so-called swarm-spore was probably not wholly unconnected with the existence of unfavourable conditions, *e.g.*, bacteria on the cell wall, deposits of lime on the cell wall, &c. *Mesocarpus*, another filamentous alga, carefully protected its chlorophyll plate from too bright light by turning it so that it should receive the proper amount only. Should external conditions be exceptionally unfavourable the protoplasm of the various cells powerfully contracted, and the filament resolved itself into the various constituents which sank to the bottom of the river or pond and there divided up and started afresh. A special point worthy of notice was the various adaptations by members of the same order in the matter of seed distribution. In *Schizocarpum filiforme* the seeds escaped through a number of slits in the wall of the fruit. In *Ecbalium elatine* the seeds were violently and explosively shot out in consequence of the sudden rupture of the fruit stalk. *Sechium edule* was indehiscent and contained only one seed. *Zanonia macrocarpa* dehisced at the apex by means of valves, and let out winged seeds of extraordinary beauty, which, aided by the wind, could cover appreciable distances. Then various adaptations by members of the same genus were shown by the *Clerodendrons*. *Clerodendron Kœmferi* attracted ants by small glands on the leaf and calyx. *Clerodendron fistulosum* did the same, but also provided a home for the ants in its hollow stem. *Clerodendron cephalanthum* climbed by means of peculiarly modified leaf stalks had a multiplicity of buds on the axil of each leaf (instead of the usual one), and also possessed glands upon its leaves. Such families as this might well be regarded as accomplished, but at the same time their various contrivances were simply so many marks of a cruel and fierce fight. Dealing with protective contrivances associated with new annual growth and germination, the lecturer instanced the *dioscorea sp. nov.* which at each new period of growth produced at first inconspicuous shoots with small leaves which were peculiarly modified into climbing organs. When well established and in the possession of a proper support large green leaves appear. In the *hodgsonia heteroclita*, here again the shoot on its first appearance was dark purple and inconspicuous with the leaves present merely as scales. It could then scarcely be seen in the tropical forest. Moreover, it was a lateral shoot, and not the main terminal shoot which it first protruded above ground. A second lateral and the main terminal were held in reserve against possible accident. When it had reached a certain height it produced the normal large leaves. He then touched upon the accummulation protective contrivances in the same individual, and instanced the *blumenbachia hieronymi*, in which the flower was at first upright and was fertilised in that position. As the fruit developed the flower-stalk elongated and the fruit was gradually and gently placed upon the ground. Until quite ripe it was protected by stinging hairs. Later on these withered and the fruit was distributed by means of a second series of grapple hairs which clung firmly to any passing animal. In the *strophanthus hispidus*, the fruit when ripe opened and let out a number of magnificent seeds, which were carried by the wind. The hairs forming the plume were sensitive to moisture and dryness, and were each capable of moving through an arc of 180°. The hairs spread out in dry weather, so that the seed might be carried by the wind. They closed up tightly when the rains came, so that they might not interfere with the placing of the seed close to the ground and its consequent germination. Sooner or later they broke from the seed. Then there were particular adaptations contrived for particular classes of insects, &c. Ants were caught and killed at Kew by flowers of *Eria stricta* (an orchid). The ants were too large for the flower, but they visited it for the sake of the honey and got caught in the mucilage. Thus both flower and ant suffered. In some instances animals and plants appeared to strive with each other, and as the one developed a particular protective contrivance, the other likewise adopted some plan to counteract it and annul its efficiency. Thus the Canari nut (the fruit of *Canarium commune*) developed a hard shell which protected it from most enemies, the black cockatoo (*Microglossus aterrimus*) reciprocated by developing a wonderfully strong beak, which appeared, indeed, to be developed with a special view to the Canari nut. Insects also often imitated parts of plants for their own benefit.—The lecture was illustrated by a large number of beautiful lantern views.

Sir JOHN LUBBOCK said their president had done him the honour to commission him to propose to them a vote of thanks to the lecturer, which he was quite sure they would pass with acclamation. He thought they would agree with him that while they had concurred with everything that had been said by their president during the past week, there was nothing more true than the words with which he had introduced the lecturer, Mr. Gardiner, and that the pleasure which he predicted they should experience from the lecture had been most amply fulfilled. (Applause.) He thought the idea which Mr. Gardiner had given them of the plants must have surprised some of them—at least who had not followed the recent course of botanical study. Mr. Gardiner began by telling them that plants were deprived of covering, that they worked very hard, and that they had to undergo a struggle for existence. entirely reversing the old saying that although they toiled not neither did they spin, still they were clothed in a more beautiful manner than Solomon in all his glory. (Laughter and applause.) But if, perhaps, in some respects the idea which Mr. Gardner had given them had been that plants did not enjoy quite so happy an existence, and were not quite so free from care as they had been in the habit of attributing to them, yet, perhaps, they might derive some comfort from the reflexion that after all, perhaps, there was as much happiness in the struggle as in the existence itself—(hear, hear)—and that if they came to look upon existence as a whole, they must less and less attach importance to the idea of the happiness of any single individual so long as the happiness of the whole race was increased. (Hear, hear.) As we looked at the ordinary plants which surrounded us, few, very few, unfortunataly, had any idea of the variety of interesting problems which they presented to us. The very complexity and vastness of the study had perhaps to some extent been the cause of this, because most of the ordinary text books upon botany were occupied to so great an extent with the descriptions of the species and mode by which one plant could be distinguished from another that very few of them, comparatively, could fine space for these interesting problems, which had added so much interest and so much vitality to our idea of plant life. But he thought that Mr. Gardiner had shown them very clearly how much interest there was to be derived from watching the habits of any single species of plant, and he could not doubt that they would all of them go away from that hall with a great variety of new ideas and many subjects for reflexion, and that as they enjoyed many a walk in the future, they would look back upon that lecture and they would renew the vote of thanks to Mr. Gardiner that he now had the honour of proposing to them. (Cheers.)

Professor MARSHALL WARD seconded the motion, which was cordially carried. The lecturer having replied, the proceedings terminated.

MEETING OF THE GENERAL COMMITTEE.

A meeting of the General Committee of the British Association was held in the afternoon in the Lecture Hall of the College of Medicine, Bath Road, Newcastle. There was a large attendance, and the chair was occupied by Prof. Flower, President of the Association.

Before commencing the proceedings, the Chairman said he had been requested by Prof. Garnett to announce that a photographer would be in attendance at the College of Science directly after that meeting was over, and it was hoped that all the members of the General Committee would, if possible, attend, and have their features consigned to posterity. (Laughter.)

THE PLACE OF MEETING IN 1891.

The CHAIRMAN said that meeting was convened for the purpose of determining upon the place of meeting in 1891. Invitations had been received from Cardiff and Edinburgh. They would also proceed to the election of officers and council for the ensuing year. The names of the deputations were as follows :—Cardiff—Ald. Lewis, J.P., deputy-mayor; J. V. Jones, Principal of the University College of South Wales; Professor Thompson, University College; Councillor Price, J.P., Mr. T. Foster Brown, C.E., and Mr. R. W. Atkinson, hon. sec. Cardiff Naturalists' Society. Edinburgh—Corporation of Edinburgh, Bailie Russell and Councillor Colston; also Sir Wm. Turner, Edinburgh University, and Dr. Geikie, Director-General Geological Survey.

Ald. LEWIS said he very much regretted the absence of the Mayor of Cardiff, as a prior engagement prevented his coming to Newcastle. The committee would remember that he appeared before them at Bath last year upon the same errand, when he made the best use of his persuasive eloquence; but Leeds was the place selected for the meeting in 1890. That was the second time of asking —(laughter)—on behalf of Cardiff, and he hoped they should be honoured with the proud distinction of receiving the Association in Cardiff in 1891. (Hear, hear.) He might remind them that the kindred societies of that institution had held meetings at Cardiff, namely, the engineers, the Medical Association of England and Wales, and the Associated Chambers of Commerce; and he believed they were received and treated as they ought to be, and that they went away highly satisfied. He did not mean to tell them that Cardiff was a very scientific town, but he was happy to say that Prof. Jones was working in the direction of making Cardiff as scientific as possible. He supposed that geology was a science; and if geology meant boring into the earth and making passages underground, they were geologists with a vengeance. (Laughter.) He had felt a difficulty in saying anything about coal, knowing that they were in Newcastle, but on Sunday, while listening to the Bishop of Carlisle, he was truly inspired, for the venerable bishop almost deified coal. (Laughter.) Well, Cardiff was the largest exporter of steam coal in the United Kingdom. He hoped he might venture to say that the people of Cardiff would be able to offer them the accommodation that the association desired, but he would promise that they should receive right loyal, hearty Welsh hospitality. (Applause.)

Principal JONES, of University College, Cardiff, said it was not necessary to say much by way of emphasising the remarks of Ald. Lewis. The invitation was a hearty one, and he believed everbody in Cardiff would do his utmost to make the visit a successful one, should the invitation be accepted. On behalf of the educational institutions of Cardiff, he hoped they would give a favourable response to the invitation. (Hear, hear.)

Mr. FOSTER BROWN also supported the application, and said he could assure them there were many objects of scientific and general interest in Cardiff which the members would be pleased to observe. There were, from geological, material, and industrial points of view many matters of importance which the British Association would be interested in, and he hoped they would give a favourable consideration to the application.

Telegrams were received stating that Lord Bute supported the invitation, and that his lordship was willing to accept the position of chairman of the Reception Committee if the Cardiff invitation was accepted. (Applause.)

The CHAIRMAN said a letter had been received from the wife of Dean Vaughan, stating how very strongly the Dean and herself wished the Association might visit Wales next year.

Councillor COLSTON, one of the representatives of the Edinburgh Corporation, said they sent in an application to the Association last year that they should pay an early visit, and it was but meet that the deputation should appear there on the present occasion and renew their application. Since Edinburgh had the honour of a visit from the British Association, some nineteen years ago, there had been expended in the city on public buildings and other great works upwards of two millions of pounds sterling. The speaker enumerated the most remarkable buildings and other features of the modern Athens, remarking at the close of his address that the deputation, which represented the Corporation and the University and other learned societies of Edinburgh, had no desire to press their claims against those of Cardiff. (Cheers.)

Sir WM. TURNER said he heartily agreed with Councillor Colston as to the many advantages which Edinburgh offered for the meetings of the British Association, but if they gave way and went to Cardiff on that occasion, and offered their invitation for a somewhat later period, they should be able even to surpass themselves in the matter of accommodation; for they were engaged in the construction, as part of their university buildings, through the princely munificence of one of their members, Mr. W. McEwen, of a university hall, which he believed would be second to none in the world, both as regarded architectural features and the accommodation it would give.

Mr. **John Evans** was glad to find that there was no competition between Edinburgh and Cardiff. There was no doubt that as far as accommodation was concerned, Edinburgh would be a preferable place. Having this year met so near the Borders, and as they were going next year to Leeds, he thought the western part of the kingdom deserved attention from the association. He, therefore, proposed that the association meetings in 1891 be held at Cardiff.

Prof. **Harcourt** seconded the motion, which was carried with acclamation.

NEXT YEAR'S PRESIDENT.

Sir **Douglass Galton** proposed that Sir Frederick Abel be elected President for the meeting at Leeds in 1890, and spoke of his distinguished services in the science of chemistry, and especially in its relation to our defences, and said he had long been before the country as a most eminent scientific man.

Dr. **Gladstone** seconded the motion, which was carried by acclamation.

OFFICERS FOR 1890.

The following officers were appointed for next year's meeting at Leeds :—Vice-presidents, the Duke of Devonshire, K.G., the Earl of Carlisle, the Bishop of Ripon, Lord Grimthorpe, the Mayor of Leeds, Sir James Kitson, Bart., and Sir Andrew Fairbairn ; local secretaries, Messrs. J Rawlinson Ford, Sydney Lupton, M.A., Prof. L. C. Miall, and Prof. Arthur Smithells ; local treasurer, Mr. E. Beckett Faber. The date of the opening of the meeting was fixed for September 3rd. Prof. E. W. Williamson was re-elected general treasurer.

THE GENERAL SECRETARY.

Dr. **Gladstone** said there was a general, if not a universal, feeling that they should not part with Mr. Atchison without giving some kind of expression to their appreciation of the efficient as well as courteous manner in which he had performed his duties. He had gone out of his way to make everything smooth and agreeable, and they extremely regretted, not only the fact that he was leaving them, but the cause of it. He had been for some time suffering from ill-health, and was going abroad for change of air, and they could only express the hope that he would return restored in vigour of body and mind. (Applause.) He proposed that the thanks of the committee be given to Mr. Atchison for the able and courteous manner in which he had discharged his duties.

Mr. **Whitaker** seconded the motion, remarking that he hoped Mr. Atchison would return quite renewed in his health. (Applause.)

Sir D. Galton and Prof. Harcourt added a few remarks in support of the motion, which was heartily carried.

Mr. **Atchison** returned thanks for the compliment. He need scarcely say it was with regret that he had, at least temporarily, to sever his connexion with the association. That was the nineteenth consecutive meeting he had attended, so that the affairs of the association had to some extent occupied attention throughout a large portion of his life. He begged them to accept his thanks. (Cheers.]

Prof. **Garnett** proposed the election of Mr. H. Llewellyn Smith to the post of assistant secretary, and spoke of his educational accomplishments.

Prof. **Smithells** seconded the proposition, and referred to Mr. Smith's capacity for discharging the duties of the office.

Prof. **Everett** said it was hardly fair to go out of their own ranks to make the appointment. He thought a man should serve an apprenticeship to the association before he was made a foreman of it. (Laughter.) He proposed the appointment of Mr. Topley.

Dr. **Barron** seconded the amendment.

After some discussion, a further amendment was proposed to refer the matter back to the council.

Eventually the following motion, proposed by Mr Trueman Wood, and seconded by Mr. Allen, was carried by a large majority, viz., that Mr. Atchison be reappointed secretary for the ensuing year, and that the council be empowered to give him such assistance as may be required.

Mr. **Atchison** said he was really unable to do the work of the association, and that was the reason he did not ask to be re-elected, but he should be happy to devote the little time he remained in England as a sort of stop gap. (Applause.)

THE COUNCIL.

The following gentlemen were re-elected members of the council for the ensuing year:—Prof. W. E. Ayrton, F.R.S., Mr. B. Baker, M.Inst.C.E., Sir R. S. Ball, F.R.S., Mr. W. T. Blanford, F.R.S., Mr. W. Crookes, F.R.S., Prof. G. H. Darwin, F.R.S., Sir Jas. Douglass, F.R.S., Dr J. Evans, F.R.S., Prof, G. F. Fitzgerald, F.R.S., Dr. A. Gamgee, F.R.S., Dr. A. Geikie, F.R.S,, Prof. J. W. Judd, F.R.S., Prof. E. Ray Lankester, F.R.S., Prof. Liveing, F.R.S., Mr. J. B. Martin, F.R.S., Prof. H. M'Leod, F.R.S., Admiral Sir E. Ommanney, C.B., F.R.S., Mr. W. H. Preece, F.R.S., Prof. W. C. Roberts-Austen, F.R.S., Prof. Rücker, F.R.S., Prof. Schuster, F.R.S., Prof. H. Sidgwick, M.A.. Prof. Schäfer, F.R.S., Prof. T. E. Thorpe, F.R.S., Dr. H. Woodward, F.R.S.

The following were elected auditors :—Dr. Gladstone, Dr. Parkins, and Mr. W. Thuselton Dyer.

This concluded the business of the meeting.

THE SIXTH DAY'S PROCEEDINGS.

TUESDAY, SEPTEMBER 17, 1889.

MEETINGS OF THE SECTIONS.

SECTION A.—MATHEMATICAL AND PHYSICAL SCIENCE.

RADIATION EXPERIMENTS.

Mr. F. T. Trouton was announced to give some experiments on radiation with Professor Hertz's mirrors. Mr. Trouton intimated that he would be glad to exhibit the mirrors to any one who cared to see them in the room adjoining that in which the section met.

The President had no doubt many members would take advantage of the rich treat Mr Trouton had provided. He understood the instrument was the subject of one of Professor Fitzgerald's communications to the Royal Irish Academy.

Mr. Trouton said Mr. Fitzgerald had published only two short papers in *Nature*. These were the only publications made on the instrument.

The President remarked that they were much obliged to Professor Fitzgerald and Mr. Trouton for having brought over the instrument. (Hear, hear.)

ELECTRICAL STANDARDS.

Mr. R. T. Glazebrook read the report of the committee on Electrical Standards, which stated that during the past year the work of testing coils had gone on at the Cavendish Laboratory. The report contained tables of the value of the coils which had been tested. Further steps had been taken towards the construction of an air-condenser. Dr. Muirhead had placed at the disposal of the committee three air-condensers he had constructed. After a series of tests it was decided to procure a set of two similar condensers. These were at present in course of construction, and the committee hoped to give a detailed account in their next report. A second subject of investigation had been the specific resistance of copper. During the year, Mr. Fitzpatrick had made a series of experiments to determine the specific resistance of copper. The committee desired to give thanks to various manufacturers who had rendered assistance, and very particularly mentioned Messrs Thomas Bolton and Sons, of Cheadle, and Messrs. F. Smith, of Halifax. The results of that research were postponed until it had been satisfactorily concluded.—The report was received.

ELECTROLYSIS.

Professor O. J. Lodge presented the report of the committee on electrolysis, which gave a list of the publications circulated amongst members during last year, and referred to experiments made in the same period.—This report was also received.

Mr. W. N. Shaw read a report on the present state of our knowledge in electrolysis and electro-chemistry, and was thanked for so doing.

THE DISCHARGE OF ELECTRICITY THROUGH GASES.

Prof. A. Schuster read a paper on the "Discharge of Electricity through Gases," and gave the results of a number of interesting experiments he had made on the subject.

The President expressed the great pleasure with which he had listened to the paper. The determination of the different velocities in the torrent was one of the most novel and most beautiful things ever brought before the British Association. It seemed to confirm what they had learnt from Crook's radiometer. They were now, he thought, in a fair way to identify the dynamic action between the stratification in vacuum tubes, ripple marks on sand, and bars at the mouths of rivers. (Laughter and cheers.)

Prof. Schuster was then thanked for his paper.

DISCHARGE OF ELECTRIFICATION BY FLAMES.

Prof. Lodge (for Prof. Worthington) read a paper on "The Discharge of Electrifiction by Flames."

METAL SHEETS AND ELECTROSTATIC EFFECTS.

Professor Lodge next read a paper on "The Failure of Metal Sheets to Screen off the Electrostatic Effect of Moving or Varying Changes," which did not excite discussion.

A NEW FORM OF CURRENT-WEIGHER.

Professor James Blyth read a paper on a "New Form of Current-Weigher." He said that in the construction of balances for the measurement of electric currents greater or less difficulty had always been experienced in leading the current into the movable parts of the instrument without seriously interfering with its sensibility. Several methods had been adopted to overcome this difficulty. In some balances the current was led in by mercury cups, in others flexible leads made of thin wire spirals or thin metal strips were employed, while in the recent balances by Sir Wm. Thomson the difficulty had been overcome by means of his well-known ligature suspension. Some time ago it occurred to the author that still another form of balance might be employed, and the present paper was a short description of one he had made. The balance was of the ordinary Roberval type, with the pivot connexions all replaced by tightly stretched torsion wires. It was constructed as follows:—On a flat base board were placed two vertical uprights of wood or other insulating material about six inches apart. Between these were stretched two parallel wires in the same vertical plane about three inches apart. To the middle points of these wires were soldered the two horizontal metal bars of the Roberval. These were about nine inches long. Both horizontal bars terminated at each end either in forks or rings, placed in a horizontal plane, and wires were tightly stretched between the prongs of the forks or across a diameter of the rings. To the middle points of these last wires were attached also by soldering the vertical bars of the balance, thus completing what took the place of the ordinary jointed parallelogram of the Roberval. The vertical bars had metal terminals insulated from each other, and carried the circular discs, on the rims of which the movable coils of wire were wound. The bars passed at right-angles through the centres of the discs, and were fixed to them at their middle points. The fixed coils, which were of exactly the same diameter as the movable ones, were supported from the base board, and were placed so that one was half-an-inch above one movable coil, while the other was as much below the other movable coil. From this it would be seen that when the balance was in equilibrium the fixed and movable coils were all horizontal, in a space of about half-an-inch between each pair. The stretched wires might be either of steel or phosphor bronze, and before being finally soldered were placed under considerable tension. The current entered, say by the upper wire connecting the fixed supports, and passed to the upper horizontal bar. There it split into two, one half (supposing the resistance equal) passing to each end of the bar, and by means of the corresponding fork-wires passing through the movable coils. From the movable coils each half returned along the lower horizontal bar, and together passed out by the lower wire connecting the two main supports. From this the whole current passed first through the one fixed coil and then through the other, and in such a direction as to produce a repulsion between each pair of coils. In the constructing, care must be taken that the suspended coils were both made of equal weight, and that when the balance was in equilibrium no tension was in any of the wires. Small scale pins were attached to each vertical bar, and a bob for raising or lowering the centre of gravity, and the whole was placed on a rod springing at right angles from the middle of one of the horizontal bars. The current strength was estimated by the weight needed to restore the balance to equilibrium when disturbed by the passage of the current. A sliding weight might also be used as in a steelyard. It would be readily seen that as in all forms of current weigher, the weights were proportional to the square of the current strength.

Professor Blyth was thanked for his paper.

AN ELECTRO-CHEMICAL PHENOMENON.

Professor S. P. Thompson read a paper on "A Phenomenon in the Electro-chemical Solution of Metals." We give the following extract:—The author described a phenomenon originally discovered by Planté, which occurs when a current is passed between two copper wires immersed in dilute sulphuric acid in a cell. The solution takes place in two stages, the metal first oxidising and then the oxide dissolving in the acid. This was projected on the screen, the audience being able to observe that the bubbles evolved when the current was turned on, ceased as the current died down choked by the formation of oxide, but almost immediately recommenced to flow when the oxide began to dissolve. The author had tried other metals and other acids—silver, zinc, and iron, sharing similar effects in sulphuric acid, but not in nitric, acetic, or hydro-chloric acids.

THE VALUE OF CHROMIC ACID.

Mr. J. Wilson Swan read a paper on "Chromic Acid as a Depolariser in Bunsen's battery." Chromic acid, he said, was very much less costly now than it was some time ago. Thanks to the initiation of Mr. W. Rowe, chromic acid was now manufactured in large chemical works instead of in laboratories, and the price of it when it might be bought in the markets brought it into competition with nitric acid as a depolariser of Bunsen's battery. He then related experiments he had made, and illustrated the different results obtained between the use of anomic and nitric acid.

After some remarks from Mr W. H. Preece and Lord Rayleigh, who occupied the chair during the temporary absence of Sir Wm. Thomson, the acting president, Mr Swan was thanked for his address.

VARIABLE STANDARDS OF SELF-INDUCTION.

Professor J. Perry read a paper on the "Variable Standards of Self-Induction," in which he said the importance of having standards of self-induction had only come home to them now, when alternating currents were used for electric lighting. The author described the standard which he was supplying to physicists for whose accuracy he was responsible.

Sir Wm. Thomson and Lord Rayleigh acknowledged the importance of these instruments, and their own obligation to give the author suggestions for improvement which he asked for.

A TWISTED STRIP VOLTMETER.

Professor Perry read a second paper on "A Twisted Voltmeter." The author described the curious behaviour of a twisted strip of metal. When elongated the ends rotated, and hence such a strip was useful in weighing machines andother many measuring instruments. Thestrip used by him on a weighing machine needed only an elongation of one one-thousandth of an inch for a rotation of the pointer of one hundred and eighty degrees. A fine double twisted strip of platinum silver has its ends fixed, it is kept of constant length, and is under tension. When electricity passes through it, the strip heels, and a pointer at its middle rotated through nearly 360 degrees. It is wonderfully accurate as a voltmeter, and is probably the very simplest instrument in existence.

ELECTRIC CURRENTS AND CONDUCTORS.

Mr. W. H. Preece, F.R.S., read a paper on "The Relative Effects of Steady and Alternate Currents on Different Conductors." Last year, he said, at Bath, Sir Wm. Thomson startled the electrical world by showing that alternating currents only entered into the substance of a thick copper conductor to a depth of about three millimeters. The fact that rapidly alternating currents were found on the surface was generally known. It was almost impossible to prove the truth or untruth of the statement of Sir W. Thomson. It was almost beyond the reach of experiment. Having at this command certain appliances and certain means of getting conductors, he was determined to try what the influence of their alternate currents would be on such conductors as were used in practice. With this purpose he got specimens of iron, copper, lead, and platinoid conductors. The experiments were numerous and costly, and each of them lasted from twenty minutes to half-an-hour. The results were appended in a long table in the report. As regarded copper, it was very clear that, whether the current were steady or alternating, the effect of heat generated in the conductors was virtually the same, but of the different forms, the tube gave the best results, owing, doubtless, to the increased rediating surface. The performance of the iron conductor was very doubtful. Here they had a large increment of heat, due clearly to reversals of circular magnetisation. Hysteresis evidently played a most important function, and the conductor in consequence became a source of heat which varied in intensity not only with the strength of the current but also with the frequency of the alternations. The general conclusion to be drawn from the experiments was that practically no serious error had been made in the form of conductors used so much for alternating current systems, and that nothing cheaper or better had been devised than a simple stranded conductor coated with a suitable insulating coating and protected outside with lead or some impervious and strong material. They did not solve the question of the distribution of current density through the section of the conductor, but they did not show that within the range of practice the total flow of energy was the same in copper conductors whether urged by alternate or steady currents.

A discussion followed the paper, and Mr. Preece was thanked for reading it.

A NEW THERMOMETRIC SCALE.

Mr. Preece also read a paper prepared by Professor G. Forbes and himself on "A New Thermometric Scale."

FRACTURED LEYDEN JARS.

Mr. J. T. Bottomley exhibited four Leyden jars, containing fractures made by an electric current. There was, he said, nothing new about them, but they were good specimens. He then pointed out to his audience the fractures made by the electric current, and was thanked for so doing.

TAKEN AS READ.

A paper on "Kerr's magneto-optic phenomenon of the laws and application for measuring purposes," by Dr. H. E. J. G. du Bois, was to have been communicated to the section by Sir Wm. Thomson, but, on the suggestion of Sir William, who said it was long and would appear in the report of the Association proceedings, it was taken as read.

A paper on "Sparkless Electro-magnets," by Professor S. P. Thompson, and a contribution from Dr. J. H. Gladstone and Dr. W. H. Perkin on "The correspondence between the Molecular Refraction dispension and magnetic rotation of carbon compounds" concluded the day's proceedings.

SECTION B.—CHEMICAL SCIENCE.

WATER ANALYSIS.

The first business was the reading of the report of the Committee (Professors Dewar, E. Frankland, Percy F.

Frankland, Odling, and Crookes) appointed to confer with the Committee of the American Association for the Advancement of Science, with a view of forming a uniform system of recording the results of Water Analysis. The paper stated that a series of questions had been sent to chemists asking their systems of water analysis; if they objected to the use of a decimal system, and if they would support the adoption of the following method, recommended by the American Committee, of stating the constituents of a mineral water:—"That the parts per thousand of each basic element, K, Na, Li, Ca, Mg, Fe'' (Fe_2), etc., be given, and of each acidic element, such as Cl, I, S, etc., that is combined directly with a basic element, or that may reasonably be supposed to be so combined, the rest of the acidic elements to be given in connexion with all the oxygen of their salts, as usually written in our present empirical formulas, as SO_4, CO_3, PO_4, etc." From the answers received to the above questions, as well as from personal experience, we gather that there would be no reluctance on the part of British chemists to adopt a uniform and rational scheme, but for the great difficulty of rendering such a method of statement popularly understood. The report continued:—We find, however, a general readiness on the part of most analysts to adopt a uniform and prescribed system only to be departed from in special cases, and we are of opinion that it would be impossible to secure more than such a qualified consent to any one system. Although there is but little possibility of directly influencing the custom of professional chemists in their private practice, we are of opinion that it is of great importance to urge upon water-analysts the desirability of adopting some uniform system in the case of such analyses as are communicated to scientific societies or other learned bodies, and which are therefore calculated to have a circulation in countries where the imperial gallon is not recognised, and if such uniformity could be secured, there is but little doubt that the system would before long establish itself even in the case of analyses of a non-public character. As regards the method of statement which would be most suitable for general use in such published analyses, we are of opinion (1) That it should be on the decimal system, preferably parts per million (mgrms. per litre), or parts per 100,000, as parts per 1,000 (grms. per litre) would too frequently give rise to fractional results. The special advantages attaching to "parts per 100,000" are that the figures for mineral waters are not inconveniently large, nor those for potable waters inconveniently small, whilst their conversion into grains per gallon is a very simple operation. We cannot agree with the American Committee that different scales should be adopted for mineral and potable waters respectively, for such a dual system must, in our opinion, inevitably lead to confusion. (2) We attribute the greatest importance above all to the clear statement, in every case, of the actual determinations made, and that all results derived by calculation should be sharply distinguished from those obtained by direct determination. Thus we view with particular disapprobation the statement of the mineral ingredients combined as salts, unless accompanied by a clear account of the analytical data upon which this statement is founded. (3) As regards the statement of the mineral ingredients, we have considered the method suggested by the American Committee, and which consists in recording the proportion of each metallic element (K, Na, Li, Ca, Mg, Fe'', Fe_2, &c.), as well as that of each electronegative element (F. Cl, Br, I. S, &c.) contained in binary compounds, whilst in the case of oxy-compounds the electronegative element is given as combined with the whole of the oxygen (SO_4, PO_4, NO_3, CO_3, &c.) and we are of opinion that this arrangement is decidedly the most convenient for all purposes of calculation although the absence of any recognised names for these acid-groups, as well as the prevailing custom of estimating the metallic elements in the condition of bases (K_2O, Na_2O, CaO. &c.) are undoubted objections to this system. (4) That the amount of dissolved gases (O, N, CO_2, SH_2, &c.) may be most conveniently expressed either in cubic centimetres per litre or in volumes of gas per 100 volumes of water, the latter being the more general practice in this country.

Mr. **Allen** and Mr. J. **Pattinson** spoke in general support of the recommendations.

FERMENTATIONS.

A paper was read by Professor **Percy F. Franklin**, **Grace C. Franklin**, and J. J. **Fox**, on Contributions to the study of Pure Fermentations, of which the following is an abstract:—The authors point out how very few of the bacterial fermentations hitherto studied have been performed with ferments of undoubted purity, as well as the insufficiency of the description of the morphological characters of the organisms in question. Such scanty descriptions generally render it impossible for other investigators to know whether they are dealing with the same or with different ferments. The authors have isolated and fully characterised by the modern methods of cultivation an organism, a small bacillus, which sets up fermentation not only in solutions of glucose cane-sugar, milk-sugar, and starch, but also in solutions of mannite, glycerine, and calcium glycerate. The fermentations of mannite and glycerine have alone been so far studied. In each case the products are essentially the same, viz., principally ethyl, alcohol, and acetic acid, together with smaller quantities of formic acid and a trace of succinic acid. The alcohol was separated by distillation and the quantity determined, whilst the several acids were estimated by conversion into their barium salts in the case of the acetic and formic acids, whilst the succinic acid was extracted and weighed in the free state. In the case of the mannite fermentations it was found that the amount of alcohol and acetic acid formed stood in the proportion of two molecules of alcohol to one molecule of acetic acid, whilst in the glycerine fermentations there were three molecules of alcohol to one of acetic acid. Of particular interest is the fact that the organism has no fermentative action on dulcite, the isomer of mannite, which thus furnishes a very striking instance of the selective power of micro-organisms between the most closely allied isomeric bodies. The authors were also unable to cause the organism to ferment solutions of erythrite, ethylene glycol, calcium, lactate, tartrate, citrate, or glycollate. In view of the characteristic products—ethyl, alcohol, and acetic acid—of the fermentations, the authors propose for the organism the name of *Bacillus ethaceticus*.

THE AROMATIC NUCLEUS.

Next followed a paper on "The Aromatic Nucleus," by Mr. S. A. Sworn, B.A., who said:—The stability and other properties of the aromatic nucleus are to be explained by assuming that the six atoms are situated at the most symmetrical positions in space—viz., at the angular points of a regular octahedron. Such positions are most consistent with the compactness of the molecular structure. It must not, however, be supposed that the atoms form a rigid structure. By their positions in space we mean merely the mean positions about which they oscillate. That they are in vibration is evident from Hartley's work on the absorption by aromatic compounds of the ultra-violet rays. In order to gain an exact knowledge of the nature of this vibration, it is certainly necessary to know the points about which vibration occurs—that is, the mean positions of the atoms. Two octahedral formulæ have been proposed—viz., those of Meyer and Thomsen. The former is a modification of Ladenburg's prism symbol. The latter is a development of the diagonal symbol of Claus. They are in a manner complementary to one another, as when superposed they form a complete octahedron. They explain equally well the relationships of the benzene substitution derivatives. No other octahedral symbol will account for these relationships. Each is characterised by para-linkage, and it may be shown that experimental work necessitates the assumption that there is direct para-linkage in the aromatic nucleus. A symbol, such as that proposed by Armstrong, is, if not meaningless, quite opposed to experimental facts. Thomsen's symbol must be preferred to that of Meyer, inasmuch as the latter is inadequate for the representation of many experimental facts. A further development of Thomsen's symbols afford a full explanation of the meta- and para-laws of substitution. Lastly, the acceptance of any symbol which adequately explains the properties of benzene necessitates a modified view of the Van 't Aoff theory. This theory must be regarded, not as affording any solution of the true positions in space of the atoms, but merely as indicating in a very rough way the general direction in which particular atoms lie. Isomerism, as explained by the Van 't Hoff theory, is merely an answer to the question—On which side of a given line or plane is a certain atom situated? A solution of this question although important, is by no means a final solution of the far more difficult question of the space relationships of the atoms in a molecule.

The PRESIDENT remarked that the paper would have been more valuable if it had more result of experiment and less of criticism on other people's experiments.

Professor FETTIKAR having addressed the section in German,

Mr. SWORN replied.

BENZOQUINONE AND POTASSIUM CYANIDE.

Mr. SWORN then read the following abstract of a paper on "The Reaction of Benzoquinone with Potassium Cyanide," as under:—Hydrocyanic acid does not form a compound with benzoquinone. The latter body, however, readily combines with potassium cyanide to form a dark green body, which is obtainable only in aqueous solution. One molecule of the quinone combines with one of the cyanide. Anthraquinone does not form such a compound. Hydrocyanic acid (but no quinone) is given off when the solution is boiled, and quinone is liberated by the addition of silver nitrate solution.

NEW WHITE LEAD.

Mr. J. B. HANNAY read a paper on "A New White Lead." After glancing at the present general and dangerous method, and remarking on the wide distribution of galena, he remarked that a new form of condenser had been devised as the result of many experiments, and by means of diagrams he described its form, method of construction, and use. In connexion with it, a Root's blower was at first used, but a steam jet was later used. The first process did not give very equal results, sometimes very pretty white lead was obtained, sometimes not so good. He then described the furnace now in use, from diagrams. He claimed that many advantages were possessed by the process and product, amongst them being that the new process started with lead ore, instead of with smelted lead, as in ordinary works; the new white lead is made in a day instead of many weeks; and the manufacture by the new process is innocuous to the workmen. He added that only men (no women) were employed in the new manufacture. As to the product, it was now largely made and used. Mr. Holman Hunt and other artists had used large quantities, and the manufacture was one of our growing industries, large works in Glasgow having produced considerable quantities for some time. The following abstract will best show the old and new methods:—The old process consists in smelting lead ore into pig lead, rolling it into sheets, after purifying the pig lead, submitting it to the action of acetic acid, carbonic acid, and air for about three months. Then it is corroded into crystals, which when ground to powder, levigated, and dried, forms the white lead. This series of operations takes in all about four months. By the new Hannay process, the lead ore is placed with live coke in a furnace, and volatilised by a blast of air, and thoroughly oxidised by the flame produced. The white snow-like vapour is conducted to condensers, where it is collected, washed, and dried. It forms a powder of great whiteness and high covering power. It is prepared ready for the market in as many days as the old process took months.

Mr. ALLEN and Mr. H. L. PATTINSON having asked questions on the paper, .

Sir LOWTHIAN BELL said that as an old white lead maker, much of the statement made by Mr. Hannay seemed to him heterodox, that for instance as to the effect of the ordinary white lead on temperature. As to the inconvenience of white lead which took much oil, that seemed to him a recommendation rather than the reverse, for the more completely a large quantity of oil was made into a proper pigment the cheaper it was. As to what the artist might say, it was of little value in a commercial point of view, for it did not matter to an artist who was going to get £1,000 for a picture whether he put an ounce or two more on it. But it became an important matter when there were miles of surface to cover.

THE PRIMORDIAL ELEMENT.

A paper followed by Dr. ISAAC ASHE on "Dimidium: An attempt to represent the chemical elements by physical forms; with models, from hydrogen to nickel, constructed in accordance therewith." The author pointed out that when the combining weight of an element was divided by the number representing its combining power, or valency, as compared in both cases with hydrogen, the quotient in many cases presented the fraction one-half. instead of an integer number; and in many other cases, particularly in the triad series, an integer quotient with unity for a remainder, was to be obtained by doubling the combining weight before dividing. Hence he inferred that an element having half the weight of hydrogen would be found to be the primordial element out of which the other elements were constructed. This hypothetic element he proposed to call dimidium. The number of atoms of dimidium which would go to form any given element would be double the number representing the combining weight of that element as compared with hydrogen. Dimidium itself might probably consist of a number of vortex rings —according to Sir W. Thompson's theory—placed one on the top of another, thus forming an elongated circular bar; a limit would be placed to the length of the bar so compacted, in consequence of a point being reached on each side of the centre, in a lengthwise direction, where the forces of attraction and repulsion between the rings balanced each other. Possibly the hollow tube thus formed might itself be filled with some still lower form of matter, out of which the vortex rings themselves might have been made, perhaps, perfect spheres, to which Mr. Crooke's term "protyle" might be applied. Assuming, then, the existence of this primordial linear element, and representing its atoms by small metallic bars of brass wire, the author showed that—taking in each case the number of bars indicated as above, by doubling the combining weight of each element—he had been able to construct a series of models of the chemical elements, in which their combining power, their positive or negative condition, and their modes of combination were all expressed, as well as their combining weight. He further showed that the forms brought out in these models corresponded with the crystalline forms known to belong to certain of these elements; and how the phenomenon of the expansion of water when freezing might be explained by reference to the form employed for the molecule of that compound, which was hexagonal in its general outline. The forms adopted for the elements in these models were also shown to correspond with the arrangement of the elements in series by Newlands and Mendelejeff, elements belonging to the same series having corresponding forms. The author suggested that simple geometrical forms, that is to say, the equilateral triangle and the square, were the combinations into which the primordial element would first have entered, and all the models were accordingly constructed out of these forms, along with the simple bar. Thus the atom of hydrogen was constructed of two single bars placed side by side, and the molecule of four, and he suggested that these were probably separated in the gaseous condition so as to form a hollow cube. There were other secondary forms constructed out of the triangles and squares, and the models of many of the elements were then constructed out of these secondary forms. Lithium was formed of two squares and two triangles, or 14 pieces, its combining weight being 7. Carbon was formed by placing two pyramids base to base, each pyramid being formed of four equilateral triangles, in all 24 pieces, its combining number being 12. The crystalline forms, both of the diamond and of graphite, were shown to correspond with this, the former being made by placing a number of the carbon atoms together by their edges, and the latter by placing them in apposition by their triangular facets. Silicon was formed by replacing each of these triangles by a group of seven, formed of two triangles united at their bases and separated at their vertices by a single bar component. This was shown to correspond with the crystalline forms of silicon. Sodium and potassium were so constructed as to correspond with the form adopted for lithium, these being all members of the same series. Similarly magnesium and calcium were so constructed as to correspond with beryllium; phosphorus and vanadium with nitrogen, sulphur with oxygen, chlorine with flourine, &c. Iron, and the group of tetrad elements analogous with it, were constructed out of a common base form consisting of 88 components, to which pairs of secondary forms, consisting of 20: 22, and 24 components respectively, were added to represent chromium, manganese, and iron respectively. The forms adopted for all these elements corresponded with that representing aluminium, so that the replacing of an atom of this latter element by one of any of the former in the alum compounds was shown to be in accordance with the theoretical forms assigned to these elements. The author suggested that probably metals combined with non-metals by lateral interpenetration, a salient angle of the former corresponding with a re-entrant angle of the latter; but that two non-metals combined by superposition, corresponding angles being applied one to the other. The union of boron with nitrogen at a high temperature was shown by reference to the models to be an illustration of this view.

MISCELLANEOUS.

Afterwards, Mr. P. J. Hartog read a paper on "Researches on Sulphides," and one by Dr. J. B. Cohen on "Metallic Aluminium as a Chemical Reagent" concluded the work of the section, Professor Liveing moving a vote of thanks to Sir Lowthian Bell, which, being seconded by Mr. Nicoll, was carried by acclamation.

VISITS TO WORKS.

A large number of the members visited the works of Charles Tennant and Partners, Limited, at Hebburn, where they had the opportunity of observing the processes in the manufacture of soda ash, soda crystals, and bleaching powder. Mr. James Tennant and Mr. Stuart acted as guides. Afterwards the works of the Tharsis Company, near at hand, were also visited by a large company.

SECTION C.—GEOLOGY.

THE GEOLOGY OF TORRES STRAITS.

Professor A. C. Haddon, M.A., M.R.I.A., read some notes on the Geology of the Torres Straits. In his paper he said:—After having examined a number of the islands in Torres Straits, I can fully confirm the triple division of the islands made by Jukes. The lines of longitude 142° 48′ E. and 143° 30′ E. conveniently demarcate these subdivisions. The islands to the west are all composed of old igneous rocks and surrounded by fringing reefs. The central group is composed of low coral islets formed by wind and wave action. The eastern islands Uga, Erub, and the Murray Islands, are of volcanic origin, and are also fringed with coral reefs. There are numerous large and small coral reefs in the Straits, but no atols. I have satisfied myself that Torres Straits is not an area of recent elevation, no traces of raised beaches or elevated coral formations were observed. The coral beach-rock on Nagi, recorded by Macgillivray, can, I believe, be accounted for without invoking an elevation hypothesis. Depression of land is less easy to demonstrate than elevation, but of this also no evidence could be found. Of the volcanic islands, Mer, the largest of the Murray group, was most carefully studied. Part of the circumference of this island is composed of inclined beds of stratified volcanic ash with a quâquâversal outward dip. In the centre of the island is an old core. The northerly portion of Mer is mainly a lava stream. Here, again, there are no raised shores or deep-sea deposits.

ANCIENT SEA BEACH NEAR BRIDLINGTON.

Mr. Watts read the report of the committee on "An ancient Sea Beach near Bridlington." The report was as follows:—No further excavation of the buried cliff beds has been undertaken by your committee during the past year; but further investigations, should they be considered desirable, will have been greatly facilitated by the removal of the talus-heaps of previous workings by the action of the sea. The tedious task of gelatinising and repairing the bones obtained last year has been proceeded with, and a part of them are now in a condition for determination. When further progress has been made, it is proposed to place the whole collection in the hands of competent osteologists for critical examination, the results of which we hope to embody in our next report. The excavated section was visited last autumn by a party which included several foreign geologists, after the meeting of the Geological Congress in London. Your committee ask to be re-appointed, without grant, for the immediate purpose of arranging for the determination and disposal of the specimens.

ERRATIC BLOCKS.

Dr. H. W. Crosskey presented a report on "Erratic Blocks." In some cases these blocks were isolated on the ground, while in other cases they were embedded. The thing to which the committee drew attention was the different levels at which those blocks were found. One of the most notable was at Franklin, near Birmingham, at 900 feet above the level of the sea. The object of the committee was to ascertain the exact position of these blocks, their distribution, their relative numbers, and the position in which they were found. He thought the committee had evidence already of the subsidence of the land at least 1,000 feet to account for the presence of those erratics. He thought if they were to trace out what happened while the land was going down—when the ice-covered land was brought into contact with the water and plunged beneath it, and then what happened on the return of ice while the land was rising, and when they had, therefore, the exposure of land freshly covered with ice and the coming down of some local glaciers—if they put these things together, he thought they might ultimately be able, by observations in the Midlands, to mark out deposits and show what happened at each of these periods.

Dr. Archibald Geikie thought that investigation would unquestionably throw a great deal of light on the geological formation of this country. They knew as yet very little of the southern limits of the ice, and Dr. Crosskey appeared to be working, if not on those limits, at least very close to them. The evidence of either a second period of glaciation or of submergence was of great interest. Whether Dr. Crosskey would succeed in proving this submergence of nine hundred or a thousand feet was, of course, a question.

A DRIFT IN THE CAM VALLEY.

Mr. W. Whitaker read a paper "On a deep channel filled with drift in the valley of the Cam, Essex." He said well-sections had given them much information as to the deep-seated geology of the London basin, and of the rising up of older wells beneath the cretaceous beds. They had now like evidence of an occurrence of the opposite kind—the deep sinking down of drift beds. In Scotland and in northern England long and deep channels filled with drift had been noticed, but not in southern England. There were, however, evidences of some such occurrences in western Norfolk, though not to the depth of the channel now in question. For some years one deep well-section had been known which showed a most unexpected thickness of glacial drift in the higher part of the valley of the Cam, where that drift occurred mostly on the higher grounds, and was of no very great thickness. Lately further evidence had come to hand, showing that the occurrence in question was not confined to one spot, but extended for some miles. The places that were mentioned ranged over a distance of six miles. How much further the drift channel might go they knew not, neither could they say to what steepness the slope of the underground chalk-surface might reach; the slopes given in each case were the lowest possible.

PRESENT GEOLOGICAL KNOWLEDGE AND AGASSIZ'S GLACIAL VIEWS.

Mr. H. H. **Howorth**, M.P., read a paper on the question, "Are the extreme glacial views developed by Agassiz and his scholars consistent with our present geological knowledge?" He said the most useful purpose of the British Association was to raise issues which were not finally settled, and which could be discussed on large grounds, rather than the reading of papers on minute subjects of geological research, which were best studied after all before an audience consisting entirely of specialists, and which could be best studied when they were put into print. The work alleged to have been done by ice was attributed to it on purely hypothetical grounds, and altogether apart from empirical tests. The ice had been made to travel immense distances, to climb up vast slopes and extraordinary molecular theories have been discussed, but the one thing which had been wanting was any empirical test at all that ice was capable of such a movement any more than the ice in his little pond at home could start on a journey and travel on to his neighbour's land. It seemed to him that they had been landed in an extraordinary set of hypotheses, which, if true, were important beyond measure, and, if not true, were standing very much in the light not only of geological reasoning, but of many other sciences. If the theory were true, of course, it was a perfectly justifiable revolution, but if it were not sustainable by overwhelming evidence, it appeared that they were standing in the light of progress if they did not raise objections to it, or at all events study the case on the other side as well as thev could. He would first call their attention to the map of the Polar area and to a phenomenon which was a most extraordinary one, and which had been singularly neglected by writers on the glacial theory. If they began with the river Mackenzie, in North-West America, and went round the Polar area, following the contour of the land along the whole length of Siberia and the Ural Mountains until they came to the longitude of the extreme east of the White Sea, almost opposite the Mackenzie, they had the most extraordinary fact that in the whole of that area there was no trace of any kind of the so-called glacial action. There was not a boulder, not a scratched rock, no drift of any sort, from one of these limits to the other. He was speaking of the result of very careful examination made in that district by other geologists for the purpose of solving that question. Nor in the Southern hemisphere was there any evidence of the work of a great ice sheet. What became of the theory of alternating climates in each hemisphere when there was ample evidence in New Zealand that the glacial period there was contemporary with that in the Northern hemisphere? In the Arctic regions Nordenskjold found no evidence of a former glacial period in the Arctic regions. Of course, he Mr. (Howorth) did not oppose the theory of local glaciers, in an ice period; the theory he combatted was that of a great ice sheet. It was proved that ice moved more and more slowly as it reached the plain from the mountains, and that when it got on to the level it ceased to move, and the ice in many districts, which was motionless, was melting.

The **President** said nearly all the geologists of Europe agreed that the glacial deposits were the work of an ice sheet. There was a reason why they did not meet with the work of glaciers on the shores of the Northern sea; they were not regions which would support glaciers. They heard Dr. Nansen the other day. That gentleman had actually crossed an ice sheet, so that an ice sheet did actually exist. Dr. Nansen found there the exact conditions which geologists expected he would find. Of course, he (Prof. Geikie) did not believe in a Polar ice cap as taught by Agassiz, nor did half-a-dozen geologists in this country. So that it looked as though Mr. Howorth had been merely setting up a bogey in order to have the pleasure of knocking it down. (Laughter.)

Prof. **Green** said Mr. Howorth had at least relieved the monotony of the section, and created some amusement. (Laughter.)

The discussion was continued by Prof. Hull, Rev. Mr. Hill, and others, and Mr. Howorth replied.

ARCTIC SHELL BEDS OF THE BASEMENT BOULDER CLAY.

Mr. G. W. **Lamplough** read a paper on "A New Locality for the Arctic Shell Beds of the Basement Boulder Clay on the Yorkshire Coast."

THE SIBERIAN RIVERS IN THE MAMMOTH AGE.

Mr. H. H. **Howorth**, M.P., read a paper on the question, "Did the great rivers of Siberia flow southwards and not northwards in the mammoth age?" He argued in favour of an affirmative reply to the question. The sea at the mouth of the great Siberian rivers would require to be raised very little to cause the rivers to flow southward. Then there could be no doubt that in the mammoth age the continents of Asia and America were connected by a natural bridge of land, which, he believed, crossed the present polar basin.

THE WITWATERSRANDE GOLD FIELDS.

Mr. E. B. **Dorsay**, Mem. Am. Soc. C.E., Mem. Am. Inst. C.E., read a paper on "The Witwatersrande Goldfields." He said:—In the early part of this year the author visited South Africa on business connected with railways and mining, which made it necessary for him to examine critically into the mining capabilities of the southern portion of the Transvaal, which section is called promiscuously the Rand, Witwatersrande, or the Johannesburg district. The mines there are more developed than those in any other part of the State. The following is a brief description of the principal features of this district. As yet there has been no scientific or systematic study of the geology of this district; all that is known of it has been discovered or developed by the working of the mines or in the search after gold-bearing veins. The geological formation consists of a series of strata of sandstone, quartzite slate, and conglomorate, all evidently deposited quietly by water. Part of the northern and eastern edge of this basin has been tilted up to an angle of 25 to 45 degrees from the horizontal by the irruption of diorite, and it is probable that the remaining portions of the vein will be found also tilted up, forming a basin over 100 miles long from east to west, and 40 miles wide north and south. The dip on the northern edge is to the south, and on the eastern edge to the west. Johannesberg was on the extreme northern edge of that basin. The formation is similar to that of coal, and will, no doubt, be found as regular as that of most coal basins. An inferior quality of coal is found in workable quantities within 200 yards of workings on the main reef which produce good gold ore; and it is very likely that ore containing gold, and coal for fuel to crush it, will yet come from the same shaft. As yet, no fossils have been discovered from which the geological age of this formation can be ascertained. The gold is contained in the conglomerate strata in quantities which vary from a trace to eight ounces per ton. There have been a large number of these strata discovered, and probably many more will be found as work progresses. These strata vary in width from a few inches to many feet, but each one when compared to itself is very uniform in its yield of gold and in thickness. In some few places the formation has been broken by the irruption of diorite, but not to the extent that could be expected when the size of the basin is considered. These conglomerate veins are called locally "banket reefs"; in this paper they will be called "veins," being merely interstratified beds or veins. They are composed mostly of quartz, quartzite, and sandstone pebbles, varying in size from an inch in diameter down, though sometimes larger, the cementing matrix being composed of oxide of iron, sand, and some clay. This cement is generally soft, but in some cases it is so hard that when the ore is broken, the quartz pebbles will break before the cementing matrix. As a rule, the pebbles contain no gold. The gold is fine, with sharp angles, not at all water worn, and showing no signs of being alluvial.

The Main Reef veins are among the lowest or deepest veins, and as the Black Reef and Zur-Bult Reef are the top or uppermost veins of this basin. As the black reef is very flat, with its north and south outcrop well defined, the main reef in depth will probably follow the same course, as all were definitely deposited in parallel strata. As work progresses in depth on the main reef, it will be found to flatten, or have a decreasing dip from the horizontal, and then to become horizontal, and perhaps rising to the surface, thus forming the southern rim of the basin. As yet no developments have been made to indicate the vertical distance between the main and black reefs. Many intermediate veins have been found between these two; some of them can be worked profitably. The first work in this district was done on the main reef, and consequently it is more developed than the others. It has been very thoroughly worked and prospected for 30 miles in length, and fairly prospected for 60 miles more. With exceptions of a few faults (forming a very small percentage of the whole length), the present development in uniform and continuous pay is over 25 miles long, with every prospect of being found to be much longer. The so-called Main Reef is composed of four parallel veins within workable distance of each other, aggregating about 15 feet in thickness, the Main Reef being about half of this; the average yield in gold varying from 8 pennyweights in the Main Reef to 8 ounces in the Robinson leader to the ton. The monthly variation in the average yield per ton in the crushings reported by individual mines is caused by varying the proportions of ore from the different veins. A larger amount from the rich leaders will cause a higher average, or a larger amount from the Main Reef will cause a lower average. The variation in the monthly yield is not caused, as many suppose, by change in the yield of the vein: each vein is fairly uniform when compared to itself. The Main Reef veins have been worked for 25 miles in length and to a depth over 200 feet, and, with some few exceptions, have been found uniform in size and yield. At present there are about 800 stamps crushing ore from the Main Reef mines, crushing about 40,000 tons, and yielding about 30,000 ounces of gold monthly, which gives an average yield of three-quarters of an ounce of gold per ton of ore; this can be taken as the present average yield of the Main Reef, which will probably be largely increased as improved appliances for saving the gold and better management are adopted. Owing to bad mining and milling in many mines (though some are very well managed) the present average expense of mining and milling is probably 30s. per ton. Estimating the gold at its market value of £3 10s. per ounce, this gives :—

	£	s.	d.
Average yield of ore per ton................	2	12	6
Less estimated expenses as now worked	1	10	0
Net profit per ton at present..........	1	2	6

This profit will probably be increased to £2 by saving more gold and economies in the working cost, resulting from better arrangement. These figures make the present value of each acre of ground underlaid by the main reef at an angle of 25 degrees, worth over £45,000 net profit, with a strong probability of being soon doubled, as better work is done in mining and milling; this amount will also increase with the dip of the vein, in consequence of increasing the tonnage per acre. The black reef vein is being worked in many places, and has been traced for a great many miles. It averages 3 feet thick, and yields in the "Black Reef" mill 16 pennyweights of gold per ton. The total cost of mining and milling this ore is less than 20s. per ton. The Zuur-Bult vein averages 3½ feet thick, and yields 1 ounce of gold per ton, at a total cost of mining and milling of less than 20s. per ton. These two last veins are the top or upper veins of the basin; as they lie very flat and level, and can be very cheaply worked, they promise to be important gold-producers in the future. The richness of the mines of this district will be seen by comparing them with other mines. For example, take the Alaska Mining and Milling Company's mine, at present the best dividend-paying gold mine in the United States. The following is the working for the six months ending June 15, 1889 :—

108,000 tons crushed, average yield per ton	$3·80
Average cost per ton of mining and milling	$1·89
Average net profit per ton	$1·91

This shows that ore yielding only about 4 pennyweights of gold to the ton leaves a net profit of one half of the gross yield. The mining laws of the Transvaal will not allow the miner to follow his vein outside of his vertical lines. As the veins are more or less flat, the purchasers or owners of mines should ascertain the extent of vein in the claims from the outcrop or point at which it enters until it leaves the claim by the side lines. This is a very important factor in determining the value of the mines in this district, and has heretofore been overlooked by purchasers. As yet nothing has been developed to indicate the depth to which the gold will be found in paying quantities. The present developed pay on the Main Reef has been proved by actual work to be at least 30 miles long, with a very uniform yield of gold and ore. It hardly seems possible that it will not be found to extend down to a great depth. All indications so far developed are that it will. The celebrated Comstock mine of Nevada, United States, might well be called a gold-mine, as the value of the bullion was and is about half gold. The richest body of ore found there was at 1,500 feet vertical depth; this deposit paid monthly dividends of £432,000 for several years. There have been a great many profitable deep gold-mines worked in the United States and Australia, many being still in good pay. Mr. C. Algernon Moring, M. Inst. C.E., F.G.S., a very high authority upon mining geology and mining, who has been examining and studying the Transvaal for the past four months, writes as follows about this district:—"The whole of this main reef series has been taken up by different companies, and I have no hesitation in saying that they are the most remarkable and the richest continuous series of gold-mines in the world; and there is not a single company but should pay large dividends if properly and honestly managed. All the conditions for working are most favourable; the climate is delightful and healthy throughout the year; the mines are easily accessible, labour cheap, and there is a plentiful supply of good coal in the immediate vicinity." For several months past about 800 stamps have been crushing ore in this district; by the first of the year there will be probably more than double this number. Say 2,000 stamps will be at work, crushing 4,000 tons of ore and producing 3,000 ounces of gold daily, or 75,000 ounces per month. This number will have to be very largely increased in order to crush in any reasonable time the ore already developed in the main reef veins, to say nothing of those required to work the ore from the black reef, Zuur-Bult, Chimes, Botha, and other veins that have been proved already and profitably worked. In 1887 South Africa produced 2 per cent. — the author estimates that this year it will produce 7 per cent., and next year over 15 per cent.—of the total annual product of the gold of the world; this last amount will be increased proportionately with the increase of additional machinery. This large increase in the annual production of gold will change the comparative value between gold and silver, unless there will be a corresponding increase in the production of silver. Gold will depreciate and silver appreciate in their comparative values. The author is aware that he is exposing himself to criticism by applying the word "basin" to a goldfield, and estimating the yield of gold by the acre—in fact, he criticised reports made in this manner before he visited this district; but after examining it, and seeing how uniform the yield and thickness of the veins were, and how closely they resembled coal formations, he decided that they should be estimated by the acre the same as coal. The author has examined closely all the principal gold and silver districts of North and South America, but in no case has he seen anything approaching this district in extent and uniformity of yield in ore and metal; veins with almost continuous and uniform pay for 25 miles in length being heretofore unknown in mining. With very few exceptions, all the mines situated on the main reef and other good reefs will pay large profits if properly worked and economically managed. These profits will increase as labour and supplies for the mines become cheaper. Large amounts of capital have been invested in this district, but there is still room for much more, that will pay large profits, provided it is invested with judgment.

MANURE GRAVELS OF WEXFORD.

A paper by Mr. A. **Bell** on this subject was taken as read.

WATERBOX DEPOSITS.

Professor F. **Clowes** read a paper "on Waterbox Deposits and their bearing on the cementing material of Rocks."

SECTION D.—BIOLOGY.

This section sub-divided itself into a department for zoology and one for botany. Canon Tristram presided over the former, and Professor Vines over the latter.

ZOOLOGY.

Dr. **Traquair**, F.R.S., read a paper on "Restoration of *Asterolepis Maximus* (Agassiz), with Remarks on the Zoological Affinities of the Pterichthyidæ."

COPEPODA IN LIVERPOOL BAY.

Mr. **Isaac C. Thompson** read a paper describing "Some new and rare Copepoda recently found in Liverpool Bay." The paper was put forward as supplementary to one read by the author at the Manchester meeting of the association in 1887, in which several species of copepoda new to Britain were referred to. The investigation of this class of microscopical crustacea had been actively continued in connexion with the scheme of the Liverpool Marine Biology Committee (L. M. B. C.), instituted by Prof. Herdman five years ago for investigating the fauna of Liverpool Bay, and of whose researches a second volume has recently been published. Ninety-four marine species of copepoda have already been found in the district, the paper referring especially to eleven of these which are new to Britain, four being new to science. The establishment of the biological station on Puffin Island at the entrance to the Menai Straits had proved of immense benefit in the investigation of marine fauna. By the use of the electric light while cruising in the steamer Hyena, belonging to the Liverpool Salvage Association, many valuable species of copepoda and other free-swimming crustacea had been taken. The paper dealt with the geographical distribution of copepoda and their gregarious habits. Their presence or absence, as influenced by commerce, formed a valuable subject of inquiry, from their value as marine scavengers and purifying agents, for, without them, waste and putrefaction would be deadly enemies, and our fish supply would be alarmingly affected, if not annihilated.

APPLICATIONS OF PHOTOGRAPHY.

Professor A. **Fraser** read a paper on "Photography as an Aid in Anatomical, Histological, and Embryological Work."

IMPORTATION AND COLONISATION OF PARASITES.

Mr. **Harmer** read a paper contributed by Mr. C. V. Riley, Ph.D., entomologist to the United States Department of Agriculture, on "The Importation and Colonisation of Parasites by other natural enemies of insects injurious to vegetation." Dr. Riley said the encouragement of the natural checks to the increase of insects injurious to vegetation might be of a twofold nature. It frequently happened that an indigenous species was found to have certain parasites in only a portion of the country which it inhabits. In such cases, where it is practicable to transport the parasites, a great deal of good may be accomplished. Cases in point were not uncommon. But this intentional distribution of the parasites or natural enemies of an injurious insect from one part to another of its native country was by no means to be compared in importance with the introduction of such parasites or enemies from one country to another, in which the injurious species has obtained a foothold, without the corresponding natural enemies which serve to keep it in check in its original home. The object of the present note was to cite an illustration of artificial introduction on a large scale, which had already been productive of great good. The orange groves of Southern California have suffered for some years from the attacks of several insects, but particularly of a very pernicious scale-insect, *Icerya purchasi*, Maskell. After careful researches, the author ascertained that the insect was, without much question, a native of Australia, and had been artificially introduced not only in Southern California but also into Cape Colony in South Africa, and probably in New Zealand; also that in its native home it rarely did serious damage, being kept in check there by various natural enemies and parasites. Last autumn and winter, he was able to send one of his field agents, Mr. Albert Kœbele, to Australia, with instructions to study these natural enemies and to send living specimens to California.

LOCAL INDUSTRIES AND THE HEALTH OF WORKERS.

Dr. **Thos. Oliver**, professor of physiology in the University of Durham, read a paper on "Our Local Industries in their social and pathological Aspect." He said:—

THE COAL TRADE.

Our oldest local industry is coal raising. The remains of Roman workings in this district bear testimony to the employment of coal as fuel nearly 2,000 years ago. Revived as an active industry a few centuries since, and maintained until the present time, the name of Newcastle has come to be associated in many minds with the cutting and exportation of coal. That the counties of Northumberland and Durham still very largely contribute to the wealth of this country, by their output of coal, is clearly seen, if we refer for a moment to Mr. Atkinson's article in the Local Guide. The output of the northern district, which includes, in addition to Northumberland and Durham, the counties of Cumberland, Westmoreland, York, and Lancaster, is equal to one-fifth of that of the United Kingdom. The number of people employed about mines, in Northumberland, is 26,278, and in Durham, 77,718, making a total, in the two counties, of 103,996. Our local coalfield is said to be compact, and the normal coal-seam varies from three to five feet in thickness—a narrow seam compared to some of the coalfields of America. We scarcely need to be reminded that the difficulty of coal raising increases with the narrowness of the seam, and its depth from the surface.

THE HEALTH OF PITMEN.

Given a population of 103,996 engaged in an industry attended by considerable risk to life from accidents alone, it is no surprise to be told that injurious effects are produced upon miners, shut up for several hours every alternate day in the deep recesses of our coal mines, breathing a hot atmosphere, and working in cramped positions. And yet miners are not an unhealthy class. To the nature of his work we ascribe the general undersize of the miner—his fairly well developed trunk and arms, and his rather undeveloped legs. Working for several hours together in a confined space, in a heated atmosphere, laden with dust and moisture, one danger to the health of the coal miner arises from inhalation of dust. This may set up an irritative inflammation of the lungs. Overstrain at work, on the other hand, may be followed by injury to the heart and blood vessels. Diseases of lungs and heart belong to the serious ailments of the miner, and by far the most frequent of his functional derangements are dyspepsia and backache. The "miner's back" is a well-known complaint, and a very troublesome one to all our colliery doctors. In other districts—more, I believe, than in this—a peculiar affection of the eyeballs has been noticed. It is known as "miners' nystagmus." The patient is unable to fix his eyes upon certain objects without their exhibiting a peculiar quivering or oscillatory movement, making clear apprehension of objects an impossibility. It is said to be dependent upon the use of the pick by the miner in a stooping or lying posture, in a working dimly lit by the ordinary safety lamp,

MINERS AND LUNG DISEASE.

Another disease incidental to the miner is that after having worked for several hours in a high temperature, and whilst in a state of perspiration, he leaves his work, comes to the foot of the shaft, up which he ascends very quickly, and is thus at once brought into contact with a colder atmosphere. Thus are inflammatory affections induced by the sudden chilling of the surface of the body, and the varied affections of the cerebro-spinal system whose termination is complete or incomplete paralysis. A few years ago the mining classes used to suffer largely, far in excess of the rest of the population, from lung disease. There was a form of miner's phthisis, known as *anthracosis*, where, on *post-mortem* examination, the lung was found to be perfectly black. If the lung was squeezed, there escaped a dirty black ink-like fluid, caused by the presence of large quantities of unburnt carbon. On microscopical examination, this could be seen buried as small particles in the walls of the pulmonary alveoli, and around the finer divisions of the bronchial tubes. These particles thus deeply buried set up an irritative form of inflammation, which resulted in an excessive development of fibrous tissue, causing the lung to become at first more solid, and, subseqently, this newly formed tissue, undergoing retraction, a fibroid phthisis, with or without accompanying tubercular deposition as the result. But all this is, to a very great extent, a thing of the past. A case of well marked anthracosis is now a very rare thing. Thanks to the good ventilation of our pits, the coal miner is now supplied with a cooler and a purer air, both of which are extremely requisite for him in his laborious calling, and also for preventing the risks to life from the evolution of fatal gases. There is now almost a general expression of opinion that miners do not suffer from any important excess of pulmonary or other diseases compared to other classes in the district, and that their occupation, setting aside the risks from accidents, is quite compatible with an average expectation of life.

HEALTHINESS OF NORTHERN COLLIERS.

Sir John Simon, in his "Public Health Reports," pays a high tribute to this district. "The healthiness of the Northern coal miners, and the lesser degrees of suffering amongst our other miners, correspond," he says, "to the different degrees of ventilation in the mines where these miners are engaged. In the Northern coal fields, good ventilation is the rule; in those of Wolverhampton, Abergavenny, and Merthyr Tydvil good ventilation is the exception. Yet, even with regard to the latter classes of mines, testimony is borne to the effects of relatively good ventilation." By it, the miner's occupation has been made less fatal. In the Welsh mines it has been shown that where the smoke of gunpowder blasting was rapidly carried away by a good ventilating current, the miners did not suffer from bronchitis and asthma, and that in other mines where the atmosphere was seldom free from smoke, almost all the miners became asthmatical as life advanced. It has, therefore, been demonstrated that, just in proportion to the dust and powder-smoke diffused through the atmosphere of the mines, so do the men suffer. It is, therefore, to a large extent, a question of ventilation. Where this is good, the health of the miner is, on the whole, satisfactory.

TUBERCULAR DISEASE.

It is interesting to inquire at this juncture as to the number of cases of tubercular disease, contributed by Northumberland and Durham respectively. There is the impression that the Northumberland miner is a stronger man, physically, than his *confrere* in Durham. Sixty-one cases of tubercular disease were admitted from Northumberland and 121 from Durham. There is, therefore, a considerable excess in the number of cases of tubercular disease coming from the county of Durham than from Northumberland. Against that, however, must be placed the fact that the total number of admissions for all classes of disease, from Durham, is greater than for Northumberland, and that the mining population of Durham is nearly three times as great as that of Northumberland. Admitting all this, the larger mining population of Durham enjoys hospital facilities far in excess of the miners of Northumberland. In the county of Durham, there are hospitals in Durham, in Sunderland, South Shields, Darlington, and Stockton. To these towns a large number of cases of phthisis and tubercular disease of all kinds must drift; and, therefore, the necessity for the mining population of Durham seeking advice at Newcastle, is not so great as in the case of the Northumberland miner. I am, in consequence, inclined to regard the Northumberland miner as healthier than his brother from Durham. Considering the nature of their occupations, and the dusty atmosphere in which they work, it cannot be said that miners are strongly predisposed to phthisis. As a class of men engaged in a laborious occupation, I do not regard them as unhealthy. To quote the Registrar-General's Report for 1885, "the mortality of coal miners from phthisical disease is excessively low compared with that of other workers." It is, therefore, not so much a tendency to tubercular disease, as immunity from it, that his statistics show, and, so much is this the case, that immunity from lung disease is sought to be explained by (1) the picked character of the men engaged in the work; (2) a protective influence exercised by the inhalation of the coal dust itself; and (3) to the microsopical character of the coal dust, which is said to be not sharp pointed like metallic dust, and, therefore, less irritating The statement "picked character of the men" no more applies, in my opinion, to miners than to other occupations, and I cannot accept the theory of Hirt, that "coal dust possesses the property of hindering the development of tuberculosis and of arresting its progress." Coal heavers who are exposed to coal dust, though not to the extent of coal miners, die from phthisis in large numbers; their rate of mortality is almost twice that of miners. Coal dust is not apparently a strong irritant to the lung, but it is certainly no protective. Too frequently we see a carbon pigmented lung, the seat, at the same time, of tubercular disease. The miner's immunity is from disease generally, and this is due to the average general healthiness of the class, the fact that most of them live in the country, and that they are not underground every day. Their freedom from diseases of the respiratory organs is due to the well ventilated state of the mines.

LEAD MANUFACTURE.

For many years Tyneside, and the North of England, have been the home of the lead trade. Many years have gone since the wealth obtained in lead mining contributed to the building up of the endowments of the see of Durham and the rectory of Stanhope. In Mr. Cookson's article in the Local Guide, attention is drawn to the development of the lead trade of this district. The marked reduction in the amounts of lead and silver ore raised in the counties of Northumberland, Durham, and Cumberland is more than counterbalanced by the large imports of lead into the Tyne from Spain, and thus it is that there is greater activity in the lead industries to-day than there ever has been. In the year 1862, the amount of white lead alone manufactured was 7,500 tons, and in 1887 it was 14,400. Such are the capabilities of the manufacturers on Tyneside, that we are told thirty per cent. more could be easily added to the output. Of all our local industries, lead-making is the one which has, unfortunately, gained for itself a bad name. Lead workers are not, as a rule, a healthy class of people. Too soon, in spite of precautions, which, it must be admitted, are not always attended to by the workpeople, many of those who are engaged in the process become indisposed. It is the workers amongst white rather than red lead that suffer the more frequently and severely, although the smelter and separater of the ore may suffer. No industry on

Tyneside sends to our medical charities such human wrecks as lead works do. On looking over the registers of our Royal Infirmary for the last five years, I find that 135 cases of lead poisoning were admitted as in-patients. Of these 91 were women, 44 were men; 8 died, 3 men and 5 women. Most of the women were young, and died soon after being exposed to the influence of lead. The 8 deaths reported do not represent the total number of deaths from the effects of lead poisoning, but only those who died from the immediate or primary effects of lead.

THE WHITE LEAD WORKERS.

The danger to the individual from the inhalation of lead begins with the process of smelting. As we have seen, the lead miner in every way escapes. Dr. Montgomery, of Blanchland, and Dr. Robinson, of Stanhope, both inform me of the healthiness of the lead miner, and of the tendency of the smelter to be affected, as also of the animals which graze in the neighbourhood where lead smelting is carried on. In Weardale, sheep and horses suffered from lead colic. A similar disease affected the animals in the district round about Leadhills, in Scotland. A hood is now placed in front of the furnace, and this has been followed by a diminution in the amount of lead poisoning amongst smelters. They are no longer exposed to the same extent to the fumes of the molten metal. I have known smelters suffer most severely from the secondary effects of lead poisoning. In one case, four sons in one family, all stalwart men, smelters, to my knowledge, died from the effects of lead poisoning, a circumstance which, supported by other experience, makes me believe in the existence of an individual and family predisposition to plumbism. The mode in which lead impregnation shows itself amongst smelters is in the production of diseases of the kidney and of the nervous system. It is not, however, amongst smelters that the pernicious effects of lead are met with. It is amongst the white-lead workers. Women and girls, for some reason or other, suffer not only much more severely, but much earlier from the effects of lead than men. In a few days, in some instances, or at the most after a few weeks' exposure to lead, either in what is known as the "white beds" or the "stoves," there is produced an anæmia which goes on increasing. Colic and headache are complained of, and occasionally vomiting and disturbances of sight, amongst which I would mention double vision and amaurosis. On examining the teeth, it is noticed that there is the well-known sign of Burton, viz., a blue line along the margin of the gum, due to the deposition of sulphide of lead.

PREVENTIVES AND PRECAUTIONS.

The excellent system which prevails at our lead works, of a weekly inspection of the workers by medical men, is one of the best preventives of lead impregnation that I know of. The slightest indication of lead contamination noticed by the medical examiner is made the occasion of a recommendation to the employers for three months' suspension from labour on the part of the lead-workers. Knowledge of this fact, however, causes the workpeople not only not to complain when inspected by the doctor, but to insist upon feeling quite well, although an hour or two after the inspection they may be found suffering from colic, and unable to follow their occupation. The high wages not only tempt them to deceive the doctor, but also the employer. Lists of the work-people who are suspended on account of illness are circulated amongst the lead manufacturers of the district. A woman suspended at one place, having recovered her health, and unwilling to be idle for three months, applies at another factory in the district for employment, using a false name. It is only by the most careful discrimination of the manager, and examination on the part of the doctor, that this rule is not more widely broken. The greatest precautions possible are taken by employers to prevent contamination of the work-people. Baths are provided, nail brushes, the use of the tooth brush is encouraged, acid drinks are provided, change of clothing, respirators, such as that suggested by Dr. Henry Newton, of this city, and washing before eating is insisted upon. Some of the firms show their anxiety for the welfare of their work-people by giving them a free breakfast before they enter upon their work in the stoves, a treat which, I am told, has been followed by excellent results. In spite of all this, however, the fact remains that, every now and then, a girl of from 18 to 25 years of age works only a few weeks or months in the lead factory, when symptoms of acute lead poisoning are noticed; colic, constipation, anæmia, vomiting, headache, pains in the limbs, and incomplete blindness are the signs and symptoms complained of. In a few days, with or without treatment, she becomes convulsed, and dies in a state of coma, the death being so sudden that we cannot but regard it as due to an acute toxæmia, and, in some way or other, dependent upon the influence of lead. At the *post mortem* no organic change is found save an anæmic, and a watery condition of the brain, and, on chemical analysis, lead is found in the various organs, *e.g.*, the brain, liver, kidneys, &c.

A PLEA FOR THE GIRLS.

Death under these circumstances, therefore, is from an acute toxæmia. No time is given for the development of secondary changes within the body. It is analogous to death from strychnine poisoning. From the hydræmic condition of the brain found after death, the inference is that there has been irritation of the vaso-motor centre, which is followed by spasm of the cerebral arteries, this induced either by the lead itself acting as a poison to the nervous system, or by a poisoned condition of the blood, due to lead, so interfering with the function of the emunctory organs, whose duty it is to throw out the effete material, the result of the wear and tear of the system. Retention and circulation in the blood of effete material is well known to bring about irritation of the vaso-motor centre, and to be a frequent cause of spasm of arteries. It is for these poor girls I plead, and for them that I ask the British Association to suggest something whereby lead making may be robbed of its dangers. Can nothing be done to diminish this tendency to lead poisoning and rapid death? The blame, I admit, is not altogether due to lead-making. There is an individual predisposition to plumbism. There is a class of women too easily affected by lead, but what that type is it is difficult to say. Very unfortuately, the class from which these people are taken are young girls, who are practically without the comforts of a good home; many of them lead a questionable life, as the statistics of another department in our Infirmary show; they expose themselves to cold, and are frequently in a state of chronic starvation before going to the lead works, and are, therefore, in a fit state for rapidly breaking down under the influence of lead. Those who are careful in regard to personal cleanliness, and well looked after at home, as a rule do not suffer. Many of the women whom I have seen in the lead factories have worked there for the last 12 or 20 years, and have practically not been ill; have scarcely missed following their occupation, save on two or three occasions when indisposed from colic, which only lasted a few days at the most. It is the ill-fed and badly housed young girl who suffers early, and women who have been married, and have lost their husbands, and having failed at other occupations, betake themselves to the lead factory, where, after a few months' service, they become victims to plumbism. Alcoholic indulgence is, likewise, a strong predisponent.

POTTERY DIPPERS AND PAINTERS.

My remarks upon lead poisoning apply with equal effect to men and women who work in the potteries, particularly to the class known as dippers, and also to painters. Painters are prone to be affected by lead. In regard to lead poisoning, I would summarise my opinion thus:—1. That women suffer much more frequently and severely than men. 2. That women suffer at an earlier age than men: that, for example, whilst up to the age of 23 men are, practically speaking, exempted, 49 women have already suffered: and that, after the middle term of life, men suffer more than women. 3. That acute lead poisoning, attended by cerebral symptoms, is much more fatal amongst women than men. 4. That the most fatal period of lead poisoning is that time in a woman's life when the menstrual function is extremely active, that this is one of the functions of the body most apt to be quickly disturbed, and that, in this way, an explanation may be found of the greater prevalence of lead poisoning amongst women. 5. That death, in the acute stage, is due to toxæmia, and in chronic plumbism, is due to organic changes in the kidneys and nervous system. 6. That gout, in this neighbourhood, is a very infrequent accompaniment of lead poisoning. 7. That Cardio-renal changes are the most frequent consequence of slowly developed lead poisoning. That, whilst the paralysis known as "wrist-drop" is more frequently met with amongst men than women, women suffer much more frequently from the accute cerebral symptoms.

SHOP GIRLS.

Milliners and shop girls suffer from the effects of long hours, and confinement in close, ill-ventilated rooms. They become chlorotic and anæmic, and thus suffer from neuralgia. As the result of girls, in shops, being too long on their feet, we find them frequently subjects of displacement of internal organs. At the meeting of the British Medical Association, in Leeds, last month, it was stated that the long continued maintenance of the upright position was, in women, a common cause of albuminuria. I cannot say that I have noticed this. What I have noticed, however, and what is much complained of, is that the food which is supplied to very many females, shut up in our large business places all day, is not sufficiently varied, and that no adequate time is given to them to take their meals.

THE DEATH-RATE OF NEWCASTLE.

Newcastle cannot boast of a low death-rate. From time to time she occupies the not too envious position of having the second or third highest death-rate of the largest towns. Infant mortality is high, and this is difficult to explain when we compare our city with other towns where infant mortality is also high. Preston and Newcastle are frequently classed together in this respect, and yet the two towns are entirely dissimilar. In the Lancashire towns most of the women amongst the labouring classes work in the cotton mills. Mothers take their infant children from a warm bed when they leave their homes for the factory at six in the morning, and deposit them for the day, frequently at some distance off, either with an elderly woman, who has charge of two or three children, or with a young girl who has just entered upon her teens. In the case of either of these foster-mothers there is a total want of knowledge of the kind of food required by the children, nor are they supplied with sufficient money to obtain it. The result of exposure to the cold morning air, and errors of diet, is, too frequently, the death of the children. But, in Newcastle, mothers do not leave their homes to work in the factories, and yet the children die in numbers far in excess of what they ought. To the effect of epidemics, we are told much of our high death rate amongst infants is due, but this should only give us a temporary, and not a high mortality rate, which is more or less permanent. Exposure to cold is a frequent cause of illness. Our winter and spring months are cold, but to those in health they are only bracing. We breathe, in Newcastle, a very contaminated atmosphere. A railway journey on either side of the river to Shields or Tynemouth will supply an opportunity for observing how deeply laden the air is with coal smoke. Perhaps it is that, in this district, manufacturers find too easily and cheaply a supply of coal. Certain it is that they do not seem to be wishful to economise their fuel. Apart from the question of waste, there is the health of the community to be considered. No manufacturer should be allowed to have his chimney stalks disgorging such large volumes of dense black smoke as we too frequently see polluting the atmosphere and darkening the district, and I cannot understand why the various local authorities on Tyneside, have not insisted upon compliance with the terms of the Smoke Nuisance Act. One thing essential to health is good air, and on Tyneside we are not allowed to have it.

CONCLUSION.

We are fortunate in having a plentiful supply of excellent drinking water, and in our city are numerous public baths and washhouses. Food is, on the whole, dear in Newcastle; dearer in many respects than it ought to be. Our Cattle Market is a gigantic institution; traffic in foreign cattle from Denmark, Norway, and Sweden, has grown into a special trade, and gives employment to several hundreds of people, and yet, in spite of the large numbers of foreign cattle landed, this district has remained free from infectious disease attributable to this source. In Newcastle, as elsewhere, recent town improvements have necessitated not only the removal of some of our old landmarks, but also the demolition of houses inhabited mainly by the working classes. Whilst destruction has gone on rapidly, there has been little or no attempt to re-establish. Houses have been pulled down wholesale, and none rebuilt in positions easily accessible to the artisan. Local philanthropy—speculation in building on the part of our moneyed classes—or the action of the Newcastle Corporation, might easily operate in this direction, and show its practical interest in this matter, by erecting substantial buildings, with all necessary sanitary requirements, such, for instance, as the Industrial Buildings—the outcome of a private speculation, which has not altogether financially proved a failure. We all believe in the great influence for good which healthy homes and surroundings have upon the people. How can we expect our working classes to rise to the moral and physical level we desire, unless we are prepared to help them in this direction? Let good, healthy, and sufficient house accommodation be secured to our workmen, and in the end the whole district will benefit. We cannot but sympathise with many of the working classes in regard to this question of house accommodation. Where, for them, is there in health that quietude so essential for reflection, and in sickness that tranquillity so indispensable for the recruitment of mind and body? These are hardships, but, if properly looked at, they act as stimuli to improvement. The higher wages received by the working classes for the last few years have enabled them to spend more money upon clothing, food, and drink. It is generally admitted that they are now better clad and fed than they ever were. I am unable to express an opinion as to whether they are more temperate in the use of alcohol now than formerly. At present, many of them are agitating for a further reduction of their hours of labour. By them the request is that 8 and not 9 hours should be the limit of the working-day. This is neither the place, nor am I in a position to express an opinion upon that demand from an economic point of view; but, speaking medically, I would say that here, as in many of our public schools, the tendency is to go to excess in leisure. Too much time is being allowed for relaxation, and games of all kinds. In the race of life, statistics show that athletes are not the longest livers. So far as this eight hours' question is concerned, we may, with all due respect to those who are putting forward the plea, ask whether our working classes have made the most of the leisure which the nine hours' movement has already given them? In many instances, they have copied, too closely, the failings of the upper classes; and we cannot but regard, with considerable regret, the marked increase in betting upon races of all kinds, now so prevalent.

The Rev. J. M. **Hick**, of Whickham, said he would like to ask Dr. Oliver whether the statistics showed much variation in the infant mortality rate of Newcastle between good times and bad times. He remembered a few years ago, during a strike at Throckley Colliery, that the death rate of infants was only about half as high as during periods of full work. With regard to atmospheric influences, he had noticed that at Lemington, when the glassworks and ironworks were in operation, there was not a single death from infectious disease, whereas when they were closed the cases became numerous.

Dr. Oliver said he had no statistics which would enable him to give the explanation desired respecting infant mortality in Newcastle. With regard to what Mr. Hick had observed in connexion with the mining population at Throckley, he presumed that he (Mr. Hick) attributed the lower death rate in bad times to some difference in the food.

Mr. Hick thought it was owing to the absence of unsuitable food.

The Chairman drew attention to the fact that in Northumberland there was a far larger proportion of hereditary coal miners than in Durham. The reason was simply that in Durham the collieries were modern, whilst in Northumberland they were very old, and, he feared, getting worked out. As regarded the lead miners, he was glad to learn that amongst them "the black spit" was dying out. But in considering the comparative healthiness of lead miners, they should remember that in some parts of Weardale and Teesdale the miners are farmers as well, nearly everyone having a plot of land of his own, and some of them were becoming agriculturists pure and simple. Dr. Oliver had spoken of the excessive leisure in schools. Well, he would be very glad if he could only feel that there were some ground for complaint on this score. He knew that in a certain class of schools which came under his observation the facts were altogether the other way, and that school teachers and their assistants, especially the young female pupil teachers, could certainly not be said to have excessive leisure.

USES OF CONCHIFEROUS MOLLUSCS.

The Rev. B. W. Gibsone, B.Sc., read a paper on "Uses of the Testaceæ or conchiferous molluscs in nature, science, and arts." The rev. gentleman, in the course of his observations, stated in detail the uses to which conches had been and might be applied, and brought out a number of curious and interesting facts bearing upon the subject.

MISCELLANEOUS.

Papers were contributed by Mr. G. Brook on "The Morphology of the Antipatharia"; by Mr. R. J. Anderson on "Some Points of Structural and Functional Resemblance in the Anterior and Posterior Limbs of Mammals"; and by Mr. G. Bourne on the work done during the past year at the laboratory of the Marine Biological Association.

The proceedings of the sub-section were brought to a close shortly before 2 o'clock.

BOTANY.

In the sub-section devoted to Botany, there were fifteen papers on the programme for the day, but one or two of these were omitted.

THE WATER IN LIVING PROTOPLASM.

Professor Marcus Hartog read a paper on "The State of the Water in Living Protoplasm," in the course of which he said living organisms were transparent; dead ones were opaque and only returned to transparency when the water they contained was replaced by a medium of much greater refractivity than water. This showed that the water of the living protoplasm must exist in some form of physical combination like water of solution or water of gelification, giving optical homogeneity.

EPINASTY AND HYPONASTY.

Professor Vines read a paper on the above subject, in which he explained that the terms referred to the structure of certain parts of the plant body. They presented two flat surfaces of different kinds. They did not grow equally in the period of growth, one side sometimes growing at a faster rate than the other, causing the leaf to curve. Hyponasty represented the growth of the lower, and epinasty of the upper surface. The object of the observations described in the paper was twofold: first, to ascertain whether the epinasty and hyponasty exhibited by dorsiventral members were spontaneous or induced, with special reference to Detmer's conclusion that epinasty is induced by light; and, secondly, to ascertain whether the change from the horizontal to the erect position, which is exhibited by many dorsiventral members on being kept for some time in darkness, was due to inherent causes, or to the action of gravity inducing negatively geotropic curvature, as urged by Frank and others.

THE VITALITY OF PASTURE PLANTS.

Professor W. Fream read a paper on "The Effects of Root-section on the Vitality of Pasture Plants." It appeared that in the course of some investigations into the herbage of old grass lands which the author carried out last year, turfs nine inches in depth were dug from a number of old pastures in England and Ireland, and transferred to one and the same place, where they were planted to permit of growth and observation. In the discussion that followed the publication of the results, it was argued that certain grasses, conspicuous by their infrequent appearance and small percentages on these turfs, had been killed by cutting at so ('shallow" a depth as nine inches. Whilst admitting the established fact that certain plants send their roots to a considerable depth, it appeared to the author that some confusion had been made between root-range, on the one hand, and the effects of root-section, on the other. Certain plants were dug up in early spring, their roots were well washed, and then the roots and root-fibres were cut through with scissors at various depths below the surface, and were afterwards planted out in poor soil and came into bloom. The experiment showed that root-section, even of very deep-rooted plants, may be performed, without fatal results, at exceedingly moderate depths.

THE ANATOMY OF PLANTS.

Dr. D. H. Scott read a paper on "Recent Progress in our Knowledge of the Anatomy of Plants," in which he reviewed the advances that had been made, and took a hopeful view of the future results to be anticipated from the adoption of more perfect methods of investigation.

BOTANIC GARDENS FOR ELEMENTARY SCHOOLS.

Mr. P. Sewell read a paper on this subject, in which he advocated the establishment of botanical gardens as an adjunct to elementary schools.

OTHER PAPERS.

Mr. M. C. Potter read papers on the "Protection of Buds against the Sun," and on the "Biology of Erythrina Lithosperma"; Prof. Hartog on "A Monadine Parasitic on Saprolegineæ"; Prof. W. Oliver gave some notes on "Davidia, a Forest Tree met with in Central China and Tonquin," and also contributed a short paper on a case of "mycorhiza." Miss Ewart described floral contrivances in the genus *Thesium*. Professor Marshall Ward read two papers—one on the "Development of a Sclerotium from Botrytis," and another on the "Recognition of Woods dug by Mr. Spurrell from the submerged Forest Beds of the Thames."

SECTION E.—GEOGRAPHY.

THE ATLAS MOUNTAINS.

The proceedings began by the reading of Mr. Joseph Thomson's report on the results of his expedition to the Atlas Mountains, which was as follows:—"It is unnecessary to dwell on my travels in the more frequented parts of Morocco. New ground was first touched on my arrival at Demat among the lower ranges of the Atlas. From Demnat I made two excursions across the secondary heights of the great range, on both occasions reaching close to the central crest. By these trips I was enabled to map out the upper course of the Wad Demnat, and partially of the Wad Tessaout. Among other discoveries of an interesting nature in this region, I may refer to the remarkable natural bridge-aqueduct of Iminifiri, which spans a deep narrow gorge, and not only carries a stream of water from one side to the other, but is also used as a bridge by the inhabitants.

Noteworthy also were some extensive ancient ruins on the top of Mount Irghalnsor, and a great series of artificial caves at Tasimset. My next line of exploration lay up the glen of the Wad Gadat from Sidi Rohal. By this glen I penetrated to the very heart of the Atlas, and crossed to the southern side of the mountains by the Tizi-n-Teluet. From the valley of Teluet I made several minor excursions, in one of which I ascended Jebel Taurirt, 11,168 feet, the first occasion on which the summit of the Atlas had been reached in this part. Proceeding farther west, a new attempt was made on the mountain fastnesses from Amsmiz. Following the Wad Amsmiz to its source, the Atlas was again crossed by the pass of Nenieri (9,962 feet), the head-waters of the Wad Nyfis were explored, and the southern slopes reached by penetrating the canyon of the Wad Agandice. Returning to the plain of Morocco, the lower mountain course of the Wad Nyfis was traced out, and Amzmiz reached by the Tizi-n-Gerimt (7,215 feet). Farther west from Amsmiz the Asif-el-Mel offered a new means of access to the main chain. This glen I explored as far as was practicable, and, then, leaving it, crossed by a new pass, the Tizi-n-Nslit (9,715 feet), to the head-waters of the Wad Nyfis, from which I made the ascent of Jebel Ogdimt (12,734ft.), the highest point of the Atlas west of the Wad Nyfis. Amsmiz was again reached by traversing the lower ranges. Six weeks were unavoidably passed in the city of Morocco, the time being profitably enough spent in a study of the social and political life of the Moors. On leaving the city, an attempt I made to penetrate the glen of Wad Urika failed. I was more fortunate by way of the Reraya. The glen of its principal tributary, the Wad Iminnen, was followed to its head, from which an ascent of the central crest was again achieved at the Tizi Likumpt (13,150ft.). From this point the Tizi-n-Tamjurt could be seen to rise 1,500-2,000ft. higher, being probably the highest peak in the entire range. From Reraya I passed on to Imintanut, from which I made my final passage of the range, and determined to my satisfactfon that the Atlas Mountains properly so called end at the Asif Ig, thirty miles from the coast, the further continuation of the elevated land being in the form of a triangular plateau 4,000-5,000ft, in height. From Agadir, where the coast was reached, the base of this triangular plateau was skirted as far sa Mogador. From Fez as a centre it had been my intention to make a series of trips into the mountains, similar to those undertaken from the city of Morocco; but the summons already alluded to stopped me *en route* at Cassablauca, and prematurely put an end to my explorations. Such as it was, however, from what I was able to do, a clearer and more exact idea of the Atlas range west of Demnat has been obtained, and its glens and mountains mapped with some approach to scientific accuracy by means of astronomical observations, careful triangulation with the prismatic compass, and route protraction with the ordinary compass. The central crest of the range has been reached at seven independent points, and heights attained exceeding previous travellers as much as 2,000 feet. Several new glens have been explored, and six passes crossed, and generally much new light has been thrown on the physical configuration of the Atlas. On these points it is unnecessary here to enter upon further detail, as I have the honour to forward along with this report the paper and map submitted to the Royal Geographical Society. Turning to geology, I am happy to report that, in spite of manifold difficulties and obstacles, I have been able to gather together sufficient material from which to construct a geological map of the Atlas range between Demnat and the Atlantic. With the exception of the work done by Maw and Hooker in 1872, absolutely nothing has hitherto been done to throw light upon the geological structure of these mountains. The comparative absence of vegetation, and the numerous deep gorges and glens cutting right into the heart of the range, in some sort went to counterbalance the incessant espionage and suspicion which dogged my every movement, and made the collecting of specimens an impossibility. The results of my geological investigations have been embodied in a paper on the Geology of the Atlas and Southern Morocco, which, along with a number of diagrammatic sections and a map, I propose to lay before the Geological Society of London. Briefly stated, my exploration of the mountains between Demnat and the sea show that they consist—(1) Of a central core or nucleus of metamorphic slates and crystalline limestones, at places much disturbed by intrusive bosses, dykes, and veins of porphyrites, basalts, and diorites. (2) Of an enormous series of red and purple shales, marls, and sandstones forming the great mass of the chain, at some points, as at Taurirt, rising to an elevation of even 11,000 feet. These, as far as can be ascertained, belong to the Cretaceous series. (3) Of an upper series of Cretaceous cream and grey-coloured limestones and sandstones, with fossils at places, among which have been determined *Trigonia*, *Arca*, *Rhynchonella*, *Astrea*, *Gryphœa*, *Astarte*, and *Lucina*. These series attain but a small development in the Atlas, as compared with the lower series, and are to be found only in the lower outer mountain terraces or steps. They are characterised by numerous intrusive bosses and great dykes of amygdaloidal basalts, which break through them along the whole length of the mountains from Demnat westward. In the plateau of Southern Morocco the red shales and sandstone series are masked by the limestones, except where some disturbance has brought the former to the surface. (4) Of later formations nothing has been satisfactorily determined. Of glacial deposits there were little more than indications at the heads of some of the glens, and at one or two places in sheltered nooks, as in the glen of the Wad Nyfis. Slightly more important accumulations were observed in the valley of Gindafy, Wad Nyfis, and in the glen of the Urika. Moraines were detected between the Wads Gadat ahd Misfiwa; and in the valley of Teluet. On the Plain of Morocco transported boulders were remarked. Upon the whole, evidences of glaciation were insignificant, and in those parts I explored I saw nothing anywhere in any way comparable to the enormous deposits described by Maw, of the soundness of whose conclusions as to their being of glacial origin I have the gravest doubt. On the botany of the expedition I have little to say, beyond explaining the extreme smallness of the collection brought back—a list of which, drawn up at Kew, accompanies this report. The whole of the time spent in the mountains was in the very driest and hottest season of the year, when for nearly eight months scarcely a drop of rain falls. The consequence is that the mountains, even to the highest points, are quite bare, and only along the courses of the streams are any plants to be found. I left Morocco just as the first autumnal rains began to fall. Very much the same remarks apply to the collection of beetles.

EASTERN NEW GUINEA.

Sir **Lambert Playfair** then read a paper on "The Jedars and other objects of interest in the district of Tiaret in Algeria." Mr. **Basil Thomson** next read a paper on "The exploration of the Louisiode and d'Entrecasteaux Islands."

THE BAHREIN ISLANDS.

The next paper was one on "The Bahrein Islands in the Persian Gulf," by Mr. J. Theodore Bent. This paper dealt with the following points:—Position and general features of the two islands; character of the seas, and the pearl fisheries—their present condition; the present government of the islands, and how these came under British protection; nature of the soil and state of cultivation; notes on the date-growing at Bahrien; journey through the interior—Mohanek, Manameh, the wells, villages of mountainous and South-Western Rufaà; the Mounds of Ali—the curious character of sepulture in vogue in remote ages in Bahrein; our excavation, and its results; on the Phœnicians in Bahrein; the Arab conquest; the Portuguese and their forts; its relation to the mainland, and road across Arabia; classical allusions to these islands; boats, architectural features, the Wahhabee influence in Bahrein; weapons, coffee-pots, inlaid bowls, and saddles; anthropology of the island.

THE CANADIAN NORTH-WEST.

The next paper was read by the President, and was one by Mr. J. G. Colmer, C.M.G., on "The North-West Territories of Canada." The paper was as follows :—

Only a few years ago that part of Canada now called Manitoba and the North-West Territories—the latter with its divisions of Assiniboia, Saskatchewan, Alberta, and Athabaska—was known as the Hudson Bay Territory, or Rupert's Land, and to the world, outside the officers of the Hudson Bay Company, it was little more than a geographical expression, so meagre was the knowledge that existed of the fertility of its soil, and of its mineral and other diversified resources. It is true that much of the country had been partially explored by Palliser and Hinde, and that a Select Committee of the House of Commons had been engaged in collecting evidence regarding it; but the subject was not one that created any great enthusiasm at the time, and the question of its being opened up for settlement, and for the use of mankind, remained in abeyance until the formation of the Dominion came about in 1867, when the young and vigorous confederation very soon initiated the negotiations which finally led to the transfer of nearly three millions of square miles, and hundreds of millions of acres of fertile land, to the united provinces of British North America.

RATE OF DEVELOPMENT OF THE COUNTRY.

The object of this short paper will be to endeavour to show with what energy and enterprise this country has been, and is being, developed, and the advantages that are likely to follow its rapid settlement by the overcrowded populations of Europe. To make such a territory accessible is after all the most practical way of utilising for the public good the geographical knowledge placed at our disposal by the intrepid explorers who invariably precede the march of civilisation. The knowledge that now prevails upon the subject, and the rapidity with which the population has augmented by the aid of immigration, are in themselves no mean evidences of the capacity of Western Canada to sustain a large number of inhabitants.

THE CANADIAN PACIFIC RAILWAY.

The story of the inception of the Canadian Pacific Railway, of the difficulties that were experienced one after another before it was taken in hand by the present company (1881), and of its final completion from ocean to ocean in the winter of 1885, are now matters of history, familiarised to us by the comparative recent date of their occurrence and by frequent repetition. The country surveyed extended from Ottawa to the Pacific coast, and from Port Simpson to the Fraser river, and the work involved an outlay of at least 3,000,000 dollars. These surveys were followed by a more general examination of the land available for settlement, north and south of the line, on a system laid down by legislation. The country was mapped out in townships of six miles square, containing thirty-six sections of 640 acres each, and a large area has been actually inspected. Copies of the sectional and township diagrams are now deposited in the offices of the High Commissioner for Canada in London, which show the general character of the land in question and contain the surveyor's notes of their examination. So complete are these maps that it is a question whether such a mass of information about so large an area of land is accessible in so small a compass for any other country. These surveys will be continued from year to year as the necessity for opening up more country for settlement arises. It is estimated that the Canadian Pacific Railway had cost Canada about £14,000,000, exclusive of the land grant of about 18,000,000 acres. To this may be added the cost of the Intercolonial Railway, a part of the through system from the Atlantic to the Pacific, say nearly £7,000,000, and there has also been spent upon the development of the North-West, and upon the land in that part of Canada, another £1,250,000. Therefore the acquisition and development of the country, for national and imperial purposes, has at a moderate computation required over £22,000,000, representing an annual outlay for interest of nearly a million sterling. No financial aid was given by the Imperial Government.

CANADA AND AUSTRALIA.

A regular line of fast vessels will soon be steaming between British Columbia and Asia, and it is believed before long between British Columbia and Australia. It is also regarded as being only a question of a few years when Canada and Australia will have direct telegraphic communication. All these things are the direct outcome of the development that has been taking place in Manitoba and the North-West, and add considerably to the significance of that great work.

MANITOBA AND THE NORTH-WEST.

Manitoba and the North-West are estimated to contain an area of about 2,700,000 square miles. The character of the country is that of a plain, rising in three steppes of different altitudes from the 95th degree of W. longitude to the Rocky Mountains. It is well watered by large rivers, the principal streams in the district inhabited at present being the Assiniboine, North and South Saskatchewan, Red, Bow, and Pelly rivers, with their many tributaries, while lakes, large and small, are to be found scattered everywhere. In the more northern districts, there are the Peace and the Mackenzie rivers, both of them of great volume. A good deal of misapprehension, arising from misunderstanding, exists about the climate. The winters are severe, but are not in any way injurious to health. Very much the same tales were told years ago about the climate of Eastern Canada that are now related about that of the West. The former is now regarded as one of the best parts of the continent for all general agricultural purposes, and time is daily showing up the climatic libels that have been perpetrated about the latter, and demonstrating its healthiness and suitability for all the needs of human existence. Not so much is now said against Canada as formerly, and this is largely attributed in the Dominion to the visit of the British Association five years ago, when the members were able to see it for themselves, and to form their own opinions as to the varied nature of the productions. The settlement of Manitoba and the North-west Territories has been much facilitated by the discovery of the immense beds of lignite, bituminous and anthracite coal that are now known to underlie an immense district, stretching from the Pacific Coast to from 150 to 200 miles east of the Rocky Mountains. Coal is being raised at Lethbridge, near Fort McLeod, and at Banff in the midst of the mountains, and a good supply of this article—indispensable where the winter is severe—is now assured at reasonable prices. As already stated, the country is very well watered, and irrigation, which is a drawback in many parts of the world where there are any large areas of vacant land, is not necessary. Not only are there plenty of rivers and lakes, but in most parts of the country good water is found at a reasonable depth from the surface. It is not intended to assert that North-West Canada is without any disadvantages, but the worst character it can be given is that it is subject to some of the vicissitudes of temperate climates, and the best proof of its suitability is found in the increase in the settlement that has taken place.

A HOME FOR AGRICULTURISTS.

As a result of the enterprise to which reference has been made, it is not surprising to learn that the population of Manitoba, the North-West Territories, and British Columbia has, within the last 12 or 14 years, risen from a few thousands to probably over 300,000. The new arrivals have come partly from the eastern provinces of Canada, and from the United States, but a very considerable number consists of emigrants from Great Britain and Ireland, and from the Continent, several flourishing settlements of foreigners having been formed along the line of the railway. At present the principal industry in which the people are engaged is agriculture, the climate and soil having proved to be exceptionally favourable for both arable and pastoral farming. In this connexion a reference may be made to a recent speech of General Butler, a well-known American Senator, in which he said that Canada has twice the extent of available wheat land possessed by the United States, and that it will produce twice the number of bushels of wheat per acre, on an average, compared with the yield in the great Republic. The country is, however, known to be rich in minerals of various kinds, and it also possesses in parts great wealth in timber. These resources in the near future are likely to receive the attention of capitalists and provide employment for the labourer. The effect of the development of the country has been to largely augment the trade of the Dominion, supplies having had to be brought in for the railways and for the settlers, and as it becomes more thickly populated the effect upon the quantity of the goods exported from Great Britain to the Dominion is sure to be considerable. Then again, the area under cultivation and occupation, owing to the liberal land regulations that have been inaugurated by the Canadian Government, is increasing year by year, and there can be little doubt that the surplus of its bountiful products available for export, after supplying the home consumption, will rapidly increase, so that the country will soon become an important factor in the food supplies of Eastern Canada and of Great Britain. Land, no matter how fertile it may be, is not of much value unless it is accessible to settlers, and unless its products can be marketed with facility and cheapness.

ADVANTAGES OFFERED TO SETTLERS.

Now that this condition of things may be said to exist in the country in question, it may not be out of place to explain briefly the conditions under which the land may be obtained. The terms are probably more liberal in Canada than in almost any other country in the world. Free grants of 160 acres may be obtained by any settler the head of a family, or by any male over the age of 18 years, on the sole condition of residence for three years, the cultivation of a reasonable portion within that time, and the erection of a suitable house. A modification of these regulations is also in force under which a settler need not reside continuously upon the homestead for the first two years; and, in these circumstances, a title may be obtained in five years. Up to the 1st January next settlers will also have the right to pre-empt a similar quantity of land, in addition, at 10s. per acre, payable in three years. These free grant lands are equal in quality and in position to any of the other lands that will subsequently be mentioned. As already explained, the country is surveyed into townships of six miles square, each containing 36 sections of one mile square. The alternate sections are available for free grants. Most of the land in the other sections belongs to various railway companies, to the Hudson Bay Company, or to land corporations, and may be obtained at prices ranging from 8s. to £2 per acre, according to contiguity to railway communication and settlement. Several experiments, both on the part of companies and individuals, and, indeed, of the Imperial Government, in connexion with the crofters, are now on trial in Manitoba and the North-West Territories, and their progress will be watched with interest. In this connexion, it may be mentioned that the president of the section is an authority on colonisation, having been connected with the experiments commenced on his return from occupying a high official position in Canada. If it can be shown, and it is believed to be possible, that persons, properly selected, and started in this way, can succeed in making a living and in repaying the capital advanced to them with interest, a great and perplexing social question will have been satisfactorily solved. It is early yet to speak positively, for hardly any of the settlements, although progressing favourably, can be said to be in the position of having succeeded, so far as returning the money advanced is concerned, except in the case of the Mennonites, who went to Canada some years ago, and who have entirely repaid the money lent to them. The experience that has so far been obtained makes it very doubtful, however, whether the money that may be advanced upon the security afforded by Canadian legislation is sufficient to enable a family to start successfully upon 160 acres of land. It has been suggested by Sir Charles Tupper that the sum should be increased to £180, which it is claimed would not only put any possibility of failure, in the majority of cases, out of the question, but would improve the security—£180 being secured upon the homestead of the head of the family and upon that taken up by an individual member thereof. In other words, 320 acres would be given as security for £180, as against 160 acres for the £120. In addition, what is even more important, it would enable the advance to be repaid more quickly than at present, and thus make the money available for the assistance of further families. In such a short paper it is only possible to touch the fringe of so extensive and so important a geographical matter as the opening up and development of a new country extending from the 49th parallel to the far North. Nothing has been said as to the recent discussions upon the Mackenzie River district and its reported immense and varied resources, or about the country that would be affected by the opening up of the Hudson Bay route, when that comes to pass; but it is hoped that enough has been said to show that a fertile country of great extent, practically unknown some twenty years ago, has in that period been opened up for habitation, and that the foundation has been laid for bringing the vacant lands now awaiting cultivation and occupation into the use for which Providence destined them, and, at the same time, providing homes and sustenance for the congested populations of the old world.

JAVA.

A paper on "The South Coast of West Java" was read by Mr. MACKINDER, M.A. In this paper the author deals with a part of Java which has not been much described. It is one of the least familiar portions of this large island, a circumstance due partly to its paucity of anchorages and to the difficulty in landing; partly to its having been allowed to become in some places a kind of menagerie; and partly, also, to the fact that it lies remote from the chief seats of government. Now that the Netherlands Indian Government are rapidly carrying out their systematic survey of the Preanger Residency, it will not be long before the south coast of West Java will be much better known than it is at present; and the recent extension of the central railway to Garoet and Tjirajap will do much to effect this end. The author's tracks over West Java would make a chequered pattern on a map; but he has thought it best not to refer to localities already well-known—localities which are now yearly visited by hundreds of visitors. Taking the central railway as his base, he performed nearly all the distance on foot, walking about 560 miles in all. In the paper he endeavoured to give a general idea of this south coast alone. The huge volcanic cones were landmarks to him, and nothing more; they had been well described by Junker and others, so he resisted the temptation of climbing them, and reserved his main efforts for the examination of the little described and remote south coasts of the Preanger and Bantam Residencies. The object he had in view was to ascertain what physical evidence there was for the belief that the west end of Java was originally united with Sumatra. In this paper the author showed that all the evidence on the Java side of the Sunda Strait points to the opposite conclusion. Zoological evidence cannot be held sufficient to establish the previous connexion between two islands without the physical evidence of such a change. The problem, as usually stated, seems to begin at the wrong end of the matter. Given the present distribution of plants and animals, it is then attempted to explain the previous arrangement of the land, and this is done too often without appealing to the physical evidence at all. In tracing geographical changes in the past, it would seem more reasonable to adopt an opposite method; but in the great majority of cases affecting the distribution of animals, it would be wiser in the first place to assume the *status quo*, and fall back when that fails on the physical evidence of the presumed changes.

This concluded the business of the section, and the president then proposed a vote of thanks to the minister and deacons of St. James's Congregational Chapel for affording the Geograpichal Section the use of the premises in which the meetings had been held.—The meeting concluded with a vote of thanks to Sir F. de Winton, which was moved by Sir Geo. Bowen, seconded by Dr. Spence Watson, and heartily accorded.

SECTION F.—ECONOMIC SCIENCE AND STATISTICS.

OUR COAL SUPPLY.

Prof. **Hull** supplemented the paper he read at Thursday's meeting of the section, dealing with our coal resources, by the exhibition of a diagram showing the rate of production of coal during the present century. This diagram showed that the coal trade had been one of great vicissitudes, and showed also that periods of prosperity had been separated periods of adversity. When the rate of production of coal was very rapid, commerce and manufacturing business were in a more or less flourishing condition; when the rate was stagnant or had receded from the previous quantity, the condition of our manufactures and commerce had not been of a very favourable character.

POOR LAW REFORM.

Mr. W. **Vallance** (Clerk to the Guardians of the Whitechapel Union) read a paper on "Poor Law Progress and Reform, exemplified in the Administration of an East London Union." After an introductory reference to the still unsolved problem of poverty, and to the varied activities which have been called forth to stem the tide of human misery, the author said that nowhere was there, side by side with a sound policy of poor law administration, more personal and practical interest in the well-being of the poor, a larger measure of co-operation between legal relief and voluntary charity, and a fuller recognition of the responsibilities which attach to churches and religious organisations in relation to service for the poor, than in the East End of London. Popularly regarded as a district of the metropolis in which wretchedness and criminality abound, it was yet strangely true how little the condition of its poor differed from that of other centres of population. Upon the basis of Mr. Charles Booth's tables, he stated roundly that in the Whitechapel Union the "lower and upper middle classes" number 6¼ per cent.; the "regular weekly workers" 71 per cent.; the "irregular and casual workers" 19½ per cent.; and the lowest class, which include "loafers" and the criminal or semi-criminal classes, but 3¼ per cent.—figures which went far, he thought, to modify the general conception of its horrors. In this district the administrators of legal relief could now take a retrospect of twenty years' resolute adherence to sound principles of relief, and see moral consequences far outweighing statistical or financial results. Up to 1870. the relief system had been that of vicariously dispensing small doles of out-door relief; the in-door establishments being reserved for the destitute poor who voluntarily sought refuge in them; able-bodied men out of employment being set to work in a labour-yard, and relieved in money and kind. Under this system the administration was periodically subjected to great pressure, the aid of the police being frequently invoked to restrain disorder, and to protect persons and property of the Guardians. The experience of the winter of 1869-70, however, was such as to lead the Guardians to review their position, and earnestly to aim at reforming a system which was felt to be fostering pauperism and encouraging idleness, improvidence, and imposture, while the "relief" in no true sense helped the poor. It was seen that voluntary charity largely consisted of indiscriminate almsgiving, that it accepted no definite obligation as distinct from the function of poor-law relief, that the poor law was relied upon to supplement private benevolence, that the almsgivers were too frequently the advocates of the poor in their demands upon the public rates, and that both poor law and charity were engaged in relieving a distress much of which a thoughtless benevolence and a lax poor law administration had created. They looked forward to the ultimate possibility of laying down a broad distinction between "legal relief" and "charitable aid," and of interpreting the former as relief in the workhouse or other institution, and the latter as personal sympathy and help. The author then traced the process of restriction (1) in "out-of-work" cases until, in the course of the year 1870, the labour yard was permanently closed; (2) in cases of sick men with families, who were relieved usually upon some condition of personal effort to avoid future recourse to the rates for support; (3) in those of widows with dependent children, who were relieved for a strictly limited period pending inquiries as to circumstances and possibilities, and efforts to place them in position to achieve independence; and (4) in the cases of "aged and infirm," in which relief was restricted as much as possible to those who gave evidence of thrift, and had no relatives capable of maintaining them; adding that even these exceptions and limitations became non-existent and unnecessary with the organisation of voluntary charity, which gradually undertook the benevolent work of saving the really deserving poor from the poor law. Thus the door of out-relief became gradually closed, and, as a fact, no cases—other than those of urgent necessity, relieved by the relieving officer in kind—have now for some eighteen years been added to the out-door relief lists. The number of out-door paupers (remnants of a former system) now remaining chargeable is but five—all aged women. The statistical tables appended to the paper showed that, whereas in 1870 there were in one week 1,419 in-door paupers and 5,339 out-door paupers relieved, in the corresponding week of 1889 there were but 1,308 in-door paupers—including 137 imbeciles not previously classified — and 46 out-door — including 38 boarded-out children—relieved. In other words, whilst in 1870 79·0 per cent. of the paupers relieved were out-door, in 1889 but 3·4 per cent. were out-door. The cost of relief in money and kind in 1869 was £7,458, and in 1889, £117. A further table gave the mean number of in-door and out-door paupers in each of the years 1870-89, from which it appeared that the mean number of in-door paupers in 1889 was 1,303 as compared with 1,311 in 1870; and that the mean number of out-door paupers in 1889 was 305 (including 216 lunatics in asylums, 41 in receipt of medical relief only, and 40 boarded-out children), as compared with 3,554 in 1870; and, further, that the ratio of pauperism to population in 1870 was 61·6 per 1,000, and in 1889, 22·5 per 1,000. The moral results of the system were next referred to in the direction of the improved condition of the poor, in their increased thrift and self-respect, and in the work of voluntary charity being more and more in the form of personal service and less in that of almsgiving. So uniform and strict has become the administration of legal relief, and so well understood is it, that an application for out-door relief is now seldom made to the Guardians. Simultaneous with the restriction of out-door relief has been the endeavour of the Guardians to make their workhouse a well-regulated establishment, and contributory, as far as possible, to character and self-reliance, as well as deterrent to the idle malingerer. In this workhouse every pauper is employed to the extent of his ability, and, as far as possible, at his own trade, the Guardians relying upon dissociation and continuous occupation for discipline, and the absence of extra diet for work, however skilled and useful, as a deterrent. The evening hours of the paupers are also usefully and profitably employed under male and female "mental instructors," whose aim is generally to exercise a salutary restraint upon conduct and conversation, and to inspire the paupers to renewed efforts to obtain an honest livelihood. Having referred to other departments of poor law administration, and sought to justify the policy above indicated, the author submitted that the existing system of legal relief does not in itself meet the more pressing needs of the poor, and that the influence of its gradual restriction will be found in a corresponding increase of sympathy between classes, and an intelligent study of the many social questions which lie at the root of our pauperism. The work of co-operation was next dealt with, and its importance enforced; the close co-operation and earnest work of the Charity Organisation Society in dealing with the more pressing needs of the deserving poor being acknowledged, and a plea urged for more voluntary work in our workhouses and infirmaries in the dispauperisation of those who have fallen by the way, and especially in the restoration to a virtuous life of young fallen women. In conclusion, it was submitted that if, as the result of a gradual abolition of out-door relief in one union, it can be said that in-door pauperism has not thereby increased, that the poor do not rely upon the poor law as they formerly did, that cases of "starvation" are of rarer occurrence, that wisely directed charity, working in concert with the poor law, has been stimulated, that the needy and deserving poor are more earnestly sought out, that the character of the poor has improved, and that both poor law administrators and representatives of organised charity are now unitedly engaged in the work of bridging the gulf between rich and poor, and in stemming the tide of hereditary pauperism, the policy which has produced these results will at least be held worthy of earnest public attention.

This paper was followed by one from the Rev. W. Bury on "Poor Law Administration and Reform," in which the author said:—There are two conflicting opinions as to the intention of the poor law; one that it exists for the relief of distress, the other that it exists for the repression of pauperism. A brief review of the history of the subject will show which opinion is the more correct. In the first instance we find the signal failure of charity alone to deal with the disease. Next, the State interfering in self-defence, but defeated in its object by the severity of its measures. Next, the State retaining its repressive measures and endeavouring to regulate charity. Then, as pauperism increased, the passing of the Elizabethan Poor Law, by which a system of legal relief was established, limited in its scope and repressive in its nature, and under a vigorous administration of which pauperism received a check. Then the administration becomes lax, the disease breaks out again, the life of the State is threatened. Government interferes once more with the poor law of 1834, which reverts to the principles of the old poor law. Finally, more recent history since 1834, and our own experience for the last twenty years, repeat the same lessons, viz., the demoralising effect of a poor law laxly administered solely as a system of relief, the necessity of a poor law which gives no scope for the indulgence of so-called charitable feelings, and which offers relief only in an unattractive form. In a word, poor law relief should only be given in the house. That this is possible and productive of the happiest results the experience of more than one union shows, *e.g.*, Atcham, Brixworth, Bradfield, St. Neots, and others. What can be done by these could be done by all; and if not an inquiry by a Royal Commission, at all events an inquiry might be made by the Local Government Board into the reasons for the flagrant contrasts which exists in contiguous unions, with a view to a new departure in the above direction.

NATIONAL PENSIONS.

The next was a paper by the Rev. W. Moore Ede, M.A., (Rector of Gateshead) entitled "A Scheme for National Pensions," in the course of which the rev. gentleman said:

After considerable experience of *laissez faire* we have now arrived at the period in our social development in which we are coming to know what problems individualism cannot solve at all, and what it can only solve imperfectly; and have arrived at the stage in which our efforts will be directed to supplement individualism by collective and national measures. Therefore, the first questions which present themselves for our consideration are—How far has individual effort succeeded in making provision for sickness and old age? How far is it likely to succeed? Is what it leaves undone of sufficient magnitude to warrant the establishment of a national system as a supplement to individual effort? Even as late as 1889 only one-half the societies made returns to the Registrar of Friendly Societies, and of these, presumably the most solvent portion, there were 676 societies, each with an estimated deficiency of over £1,000 (Co-operative Annual for 1889, p. 420). Even this, though an argument for a more perfect system of Government inspection and compulsory publication of accounts, does not seem to me to warrant a demand for the substitution of a Government system for these voluntary associations. Individual effort, guided by experience, will overcome these evils. The following table will enable us to arrive at an approximate estimate of the number of the working class insured for sickness and funeral benefit. The first five figures are taken from a pamphlet published by the Rev. J. Frome Wilkinson on mutual, friendly, and provident institutions, a reliable authority on the subject:—

	Members
Affiliated Orders	2,004,000
Centralised, General, and County Societies	500,000
Peculiar Trade Societies—	
(*a*) Railway Group	40,000
(*b*) Miners Permanent Relief	221,000
Women's Societies	10,000
Small Local Benefit Clubs which are rapidly passing out of existence owing to bad financial arrangements	750,000
Collecting Friendly Societies—	
Royal Liver	1,211,259
Victoria Legal	1,003,787
Others	594,547
	6,334,593
Deduct from Children insured in the Collecting Societies, say	1,000,000
Total number of persons secured provision in sickness by insurance	5,334,593

We must add to these the members of trades unions, as these associations also provide for sick and funeral benefit. The number of the members of the unions in Mr. Burnett's report for 1888 is 467,334; but, as he had not received returns from all the smaller unions, we may place the total at, say, 700,000.

This gives a grand total of 6,034,593. Some deduction must be made for double membership. Large as the figures are, they show that there is an enormous residuum, consisting chiefly of labourers and unskilled workers, who are not members of any friendly society, and there is the whole class of women workers, whom the friendly society system has scarcely touched. It may some day be a question whether it may not be necessary to follow the policy of the Education Act and establish a national society, which shall supplement the efforts of individualism and compel those who will not join the existing societies to become members of it. It will be noticed that I have not reckoned the members of the Prudential and other similar collecting societies, whose total membership is about 7,000,000. I have omitted them advisedly, as these societies do not secure sick benefit, and the formidable total is very largely made of insurances for small amounts on the lives of children. I might say much concerning the costliness of these societies to the working people, spending as they do in working expenses from 5d. to 6d. of every shilling received by them. The point, however, to which I desire to draw attention is that while the working classes have by self-help gone a long way towards making provision for sickness, self-help and individual effort have scarcely touched the important problem of making provision for old age. The consequence is that practically the whole working class, certainly the whole of the unskilled labourers, of this country have, as the prospect before them, as the end of a life of toil, an old age of penury, privation, and dependence on relatives already heavily burdened, or on the rates. It is somewhat difficult to obtain statistics which give a measure of the extent to which old-age poverty exists. Not very long ago Canon Blackley published some figures on the subject which led him to form the estimate that 45 per cent. of all persons, rich included, in England who reach the age of 60 years are obliged to become recipients of poor relief. A strong corroboration of the probability of Blackley's induction being near the truth is found in the fact that in 1879, out of the total number of deaths in England one out of every fifteen occurred in a workhouse, while in London one in nine was in a workhouse. It would be an inestimable boon if at the age of 65 every man was secured, just when his powers were failing, an allowance of say £1 a month—enough to free him from anxiety as to how he might exist during the rest of his days, and be sufficient to prevent his becoming a burden on children or grandchildren, themselves none too well able to support a non-earning member of the household. Such an annuity would at 65 represent a capitalised value of £116. We have therefore to face the question as to whether there is any possibility of the mass of the weekly age earning classes saving an amount sufficient to secure such an annuity. Here let me draw your attention to the following table, which represents the cost of an annuity of £12 a year at 65 years of age, purchased at the ages mentioned in the first column, and reckoned on the basis of interest at 3 per cent.

Age.	Single Payment.	Annual Payment.			Weekly Pence.
	£	£	s.	d.	
18	12·04	0	11	5	2·63
21	13·38	0	13	2	3·04
25	15·45	0	16	0	3·69
30	17·62	1	0	10	4·81
35	22·52	1	7	9	6·40
40	27·46	1	18	2	8·81

The amount, which seemed so formidable when stated as the price of an annuity purchased at 65, does not appear at all impracticable when stated as a weekly payment of 2½d. from the age 18, or 3d. from the age of 21. It would not be difficult to arrange for a deduction being made of 3d. per week on and after a certain date from the wages of all persons who on that date were over 21 and under 22 years of age; and in due course old-age pauperism would disappear, and the burden imposed would not be beyond the power of the weekly wage earners to bear. The money so deducted would have to be paid into the hands of National Pension Fund Commissioners, and all those who had such deduction from their wages made would be entitled on attaining the age of 65, to a pension of £1 a month, and would have the security of the national honour and credit that the contract which they had entered, and which did not mature for 44 years, would be kept. Security for the fulfilment of contracts at long distant dates is essential to any pension scheme, and nothing less than a national guarantee can give it absolutely. But there is a great difficulty in connexion with weekly payments which extend over life, viz., that it would be impossible to exact them when men were out of work owing to slackness of trade, sickness, or other cause; and when they returned to work the accumulated arrears might be a burden too heavy to bear. It would render the working of a national pension fund much less complicated and expensive if the contributions required were all paid in the first years of working life, and there are several cogent reasons why the payments should be made early in life. The capital sum required increases rapidly as age advances. A payment of from £12 or £13 in early manhood will, owing to the cumulative power of compound interest, secure a benefit which would require £27 10s at 40, and £116 at 65. Also—and the consideration is one of very great importance—weekly wage earners are better able to bear a deduction from wages in the early years of their working life. A payment of 1s. 8d. a week for three years, from the age of 18 to 21, or 1s. 9d. from 21 to 24, would secure an annuity of £1 per month, or 4s. 8d. per week, after 65, if we calculate interest at the rate of 3 per cent., and assume that every person who survives to the age of 65 claims his annuity. The burden could be borne by all, or almost all, male workers. But it would be more than could be imposed on women, considering the low rates of their remuneration. Ought the whole of the burden to be imposed on the wage earners? There is much to be said in favour of dividing the burden. At present the majority of the working population who are incapacitated from work by the infirmities of age are supported by contributions levied on property to the extent of several millions per annum. If all down to the very poorest are compelled to make provision for their own old age, property will be relieved of a burden it now bears, and the burden transferred to those least able to bear it. There would be nothing illogical in the nation saying every man ought to make provision for his maintenance during that period of life in which the infirmities of old age will probably prevent his doing so. It is a duty each man owes to himself, and a duty each man owes his neighbour; but as a very large proportion are during life so poorly paid, instead of asking all to pay 1s. 8d. a week for three years between the ages of 18 and 20, we will only require that they should pay half that sum, and we will give to them a pension of 4s. 8d. a week from the age of 65. Half the cost of the maintenance of people in their old age may fairly be borne by the national exchequer, *i.e.*, by the strong, healthy, and wealthy. There would be no unfairness in this. A man would pay 10d. a week from 18 years of age to 21; from 21 to 65 he would contribute his proportion to the general taxation, and, therefore, his proportion of the maintenance of those incapacitated by old age, so when he in his turn became a pensioner, he would receive the value of the annuity he had purchased, and an equivalent for the contribution he had paid out of his earnings to taxation for the benefit of aged persons. This would merely be an adoption by the nation of the principle of the family—viz., that the younger and able-bodied help to supply those past work with the necessaries and some of the comforts of life, they in their turn to be assisted by their children. Such a system would be fair, because in so far as the rich contribute more than the poor to the taxation of the country, they would, as justice demand they should, be the largest contributors to the support of old age. The receivers of rent and interest, as well as the recipients of wages, would each in due proportion assist in bearing the burden of old age.

One question and one objection I must touch upon. The question is—Do you propose that only wage-earners whose wages are not beyond a certain limit shall be entitled to be recipients of the benefits of this fund? No. Every one, from peer to plough-boy, should be required to pay in his contribution to the National Pension Fund. The nation has no security that a man who is rich at 21 will not be a pauper at 65. The objection is—as the pension is greater than the annuity which the contribution alone would purchase, and comes in part from general taxation, the system would be pauperising. Not so. There is nothing pauperising in receiving a pension at the end of working life. If there were, our civil servants, and not a few of our nobility, would be in a condition of great demoralisation. The demoralising element in poor relief is the exacting proof of destitution, the inquisition into character, and the demand of the recipient that he should be treated as on a different footing from others. A man would claim his pension as a right, not as an act of sufferance. Nor can it be said a fund would encourage idleness and the desire to be supported by the labours of others, for during the years in which a man possesses full working powers no claim could be made. Whatever may be thought of the suggestions made in this paper—of this I am convinced, that there are few measures, if any, within the range of practical politics which would conduce so effectively to the amelioration of the condition of our weekly-wage earning class, which forms the great bulk of the nation, as a well-considered national pension fund, which would relieve them from the dread of an old age of privation and misery, and secure the certainty of at least a maintenance when the powers of earning wages become impaired.

THE DISCUSSION.

Discussion then took place on the three papers.

Mr. Stephen Bourne directed his remarks to the paper of the Rev. W. Moore Ede. It appeared to him that the difficulties in the way of putting such a scheme in operation were so great that he was afraid it was almost impossible to meet it in the way indicated. Speaking of friendly societies, he said they had done a great deal of good in many quarters in cases of sickness and provision for death. But he knew a great evil which had resulted from them, and that was the fostering of indifference to infant life, and created a feeling that money might be gained by its extinction. It was a question which must come under the consideration of the Legislature, for it was widespread and great evil. He believed the insurance of infant life was an evil which had gone beyond any benefit which could have possibly arisen from it.

The difficulties of administration appeared to stand in the way of Mr. Ede's scheme. He did not see how people could be compelled to pay to such, and he looked with suspicion upon anything of the kind. Then they would have to take into account the evil which would arise from personation. The scheme, however, was of sufficient importance to warrant the closest inquiry, and if means could be resorted to by which security could be provided for those who, having lived good lives and reached an honourable age, we should be preserved from the horrors of poverty.

Mr. Leech (Manchester) said some of our institutions were pitfalls for many hard working and honest people, and it was hard that when they reached old age they should be obliged to resort to the workhouse or charity. Again, few opportunities were given to the working classes to lay by money for their old age. Something on a surer foundation than our insurance societies was required. Many contributed to friendly societies only to find when old age came they collapsed. We required some great national system, but he feared the scheme laid before them was wanting in many respects. The scheme might be beneficial, but it was unworkable, and, moreover, the working classes of the country would scarcely submit to the conditions.

Mr. W. L. Brus was of opinion that what they should do was to encourage and stimulate individual effort. They did want to endeavour by what he must call a little financial jugglery to cause one man to provide for another. Thriftless people now relied upon hospitals in case of sickness and the workhouse in old age, and now it was proposed to put before them another inducement to be thriftless. The thing was a repetition of the old pauperising poor laws under a different name.

Mr. Howard Hodgkin said it appeared to him that the scheme did not attempt to get over what, in his opinion, was one of the greatest difficulties, and that was in cases where people were out of work. If a pension could be given at such a time, one of the greatest difficulties would be got over. But to make payment to such a fund compulsory was simply impossible.

Mr. A. Macknight spoke of the necessity of raising the moral tone of the people and encouraging them in thrift. The scheme laid before them was a consummation to be desired, but the objections which had been lodged against it that day were fatal to it in its present form. It must be brought forward in another shape. He advocated the abolition of compulsory poor law. What he said was, "Raise the working people to see the necessity of a universal system of thrift, so that in old age they may be able to maintain themselves."

Mr. Botly thought if the scheme drawn up by the Rev. Moore-Ede could be carried out, it would be a great boon to the country at large.

Mr. Adam Carse, Newcastle, referring to the papers of Mr. Vallance and Mr. Bury, said it appeared to him, from Mr. Vallance's statement, the whole matter lay in the question, "Can we do without outdoor relief?" As far as Newcastle was concerned, he thought it would be a great cruelty to do away with outdoor relief. It appeared to him that the unions of Brixforth and Whitechapel, which had been referred to, were in a bad state of administration in the years 1870 and 1872 respectively. Mr. Bury, in 1872, found considerable mal-administration of the Poor Law, and Mr. Vallance had pretty much the same complaint to make, that was to say there had been a great deal of outdoor relief given without proper investigation, and the result was a large amount of public money was wasted. Whenever that was the case, he did not agree with the system adopted. He did not think people from the South could instruct people in the North in the administration of the Poor Law.

Mr. G. W. Hastings, M.P., was at one with Mr. Vallance on the subject brought forward by him. The basis of the Poor Law was not to teach the people to go on the poor rates, but to keep off if they wished to do their duty to themselves and their neighbours. If there was any cruelty in the matter of outdoor relief, it was when it made thriftless people go to the struggling shopkeeper or the poor labourer and compel them to give them something in the shape of poor rates towards their maintenance.

Mr. Vallance and the Rev. W. Moore Ede replied on the discussion. The latter stated that Germany had worked a scheme such as that he had indicated, and if Germany could do it he was quite sure England could.

HOME COLONISATION.

A paper followed on "Home Colonisation," by the Rev. Herbert V. Mills. In the paper he dealt with the necessity for work of a useful, self-supporting kind for able-bodied unemployed poor, and alluded to the badness of the present method of giving relief, which, he said, pauperised men who were willing to work. He touched upon the financial loss to the community and the moral loss of the present system. He next gave an explicit account of his proppsal, which was the organisation of men and women thrown out of employment into colonies or industrial villages where they could supply each other's needs. Within the colony there must be agricultural work and manufacturing work, and it must be controlled by a director. It must produce and consume its own products as far as possible, and it must, therefore, produce chiefly the necessaries of life—food, clothing, and shelter. The advantages of home colonisation to the general community would be great. There would be less helpless and hopeless poverty, and fewer aged poor to be maintained at the public expense. We should have a true labour test for idlers, and could get our knaves and dastards arrested, and take up a more initiative policy for the suppression of vagabondage. We should reduce the number of temptations towards vice; and a contented working class, having a direct interest in the soil, would be our best defence in time of war.

Mr. Hastings, M.P., and Prof. Geddes made some brief observations on the paper.

THE MONETARY STANDARDS.

The report was read of the committee appointed for the purpose of investigating the best methods of ascertaining and measuring variations in the value of the monetary standard. The committee had considered Professor Newcomb's method, Professor Foxwell's method, Mr. Giffen's methods, Mr. Bourne's method, Sir Rawson Rawson's method, the present writer's (Professor F. Y. Edgeworth) method, and Ricardo's method. The report continued:—In conclusion it may be useful to enumerate and summarily characterise the principal definitions of the problem, or "standards," which have been discussed in this and the preceding memorandum. An alphabetical order will be adopted, the order of merit being not only invidious, but also impossible in so far as different methods are the best for different purposes. The Capital Standard takes for the measure of appreciation or depreciation the change in the monetary value of a certain set of articles. This set of articles consists of all purchaseable things in existence in the community, either at the earlier epoch or at the later epoch, or some mean between those sets. This standard is due to Professor Nicholson. It is stated by him (in terms a little less general than those here adopted) in his book on money. It is discussed in the sixth and the tenth sections of the former memorandum. The Consumption Standard takes for the measure of appreciation or depreciation the change in the monetary value on a certain set of articles. This set of articles consists of all the commodities consumed yearly by the community either at the earlier or the later epoch, or some mean between those two sets. This standard has been recommended by many eminent writers, in particular by Professor Marshall in the *Contemporary Review* of 1887. It is proposed by the committee as the principal standard. It is discussed in the second section of the former memorandum. The Currency Standard takes as the measure of appreciation or depreciation the change in the monetary value which changes hands in a certain set of sales. These sales comprise all the commodities bought and sold yearly at the earlier epoch or at the later epoch, or some mean between those quantities. This standard appears to be implicit in much that has been written on the subject, but to have been most clearly stated by Professor Foxwell. It is discussed in the second section of this memorandum. The Income Standard takes as the measure of the appreciation or depreciation the change in the monetary value of the average consumption, or in the income per per head, of the community. This standard is proposed in the fourth and fifth sections of the former memorandum. The Indefinite Standard takes as the measure of appreciation or depreciation a simple unweighted average of the rates formed by dividing the price of each commodity at the later period by the price of the same commodity at the earlier period. The average employed may be the Arithmetic Mean used by Soetbeer and many others, or the Geometric Mean used by Jevons, or the Median recommended by the present writer. This standard is recommended by the practice of Jevons and the theory of Cournot. It is discussed in the eighth and ninth sections of the former memorandum, and the fifth section of the present one. The Production Standard is a designation which may be applied to a method which is related to the currency standard very nearly as the income standard is related to that based on consumption. The production standard takes as the measure of appreciation or depreciation the change in the monetary value per head of the total amount of things produced in the community yearly. This standard is proposed by Professor Simon Newcomb in his "Political Economy." It is discussed in the first section of this memorandum. The Wages (and Interest?) Standard takes as the measure of appreciation or depreciation the change in the pecuniary remuneration of a certain set of services, namely, all (or the principal) which are rendered in the course of production, throughout the community, during the year, either at the initial or the final epoch; or some expression intermediate between the two specified. The theoretical basis and practical construction of such a standard are indicated in Ricardo's "Principles of Political Economy (ch. xx. and elsewhere), in Professor Marshall's evidence before the Gold and Silver Commission ("Parliamentary Papers," 1888, C), and in the papers contributed by Mr. Giffen to the second volume of the bulletin of the International Statistical Institute. The standard is discussed in the last section of this memorandum.

SECTION G.—MECHANICAL SCIENCE.

BLAST FURNACES.

Sir **Isaac Lowthian Bell**, president of the B Section, opened a discussion on blast furnaces, in which Sections B and G were to take part conjointly. Sir Lowthian said the dimensions of blast furnaces differed very considerably, and in order to preserve consecutiveness in his few remarks he would assume that the members would like to have a short description of the blast furnace itself. As was well known, the air in a blast furnace entered at the lowest part. There was at that point the generation of a considerable quantity of carbon dioxide. This was only momentary, because immediately the second oxide of carbon came in contact with the coke or any other carbon at a high temperature, it was resolved into carbonic oxide, and in this condition the producing gas, as it was called, travelled upwards through the whole length of the furnace. It was quite true that there was always a large quantity of carbon dioxide found in the gases, but that carbon dioxide was exclusively generated in the upper portion of the furnace. If the interior was raised to a high temperature, the carbon dioxide formed, and was converted into carbonic oxide. He need not remind the section that conversion was always attended by a loss of heat, because the generation of carbonic oxide gave out only 2,400 calories. In 1828 a gas works manager in Glasgow conceived the idea of heating the air before it was sent into the furnace. His idea was that he was going to secure a higher temperature. That was an entire mistake on his part, so far as the blast furnace was concerned, because the temperature, in point of fact, had not altered at all by the admission of air at a high temperature. But his surprise must have been exceedingly great when he found that the burning of a few hundredweights of coal in the hot air apparatus, as it was called, was the cause of saving something like four or five times the quantity of coke in the blast furnace, and for a long time iron makers and scientific men were utterly at a loss to understand how this extraordinary change was effected. The reduction was due simply to the superior oxidation of the coke. Instead of producing only 2,500 calories, it produced 3,600. The burning of 5 cwt. of coal in the hot air apparatus, of which not more than one cwt. entered the furnace, reduced the fuel from 45 cwt. to practically 29 cwt. The next improvement, and a very important one, was by altering the height of the blast furnace. From 45 feet it was raised to 80 feet. This, of course, afforded a much longer opportunity of the gases operating upon the ore descending than there was before. As a result, they had the fuel reduced from 29 cwt. to a shade over 28 cwt. They had great difficulty in understanding how blast furnaces driven with hot air reduced the time, which was a great economy in coke. He considered, before much was done in that direction, that it was a matter of time; and that idea was confirmed by Lord Granville erecting some large blast furnaces blown with cold air. He found then that the saving was exactly equal to that which they had effected in the furnace with hot air—that he had secured a longer contact and obtained precisely the same results with cold air as they had done with hot. That, of course, put an end to any mysterious influences which the use of hot air was supposed to exercise in the furnace. The raising of the furnace to 80 feet in height raised the temperature above which Neilsen, the inventor, had got—his temperature was 600, and it was raised to 900; and those who had not studied the nature of the process naturally said, why should they not raise the furnace, if necessary, to 180ft., and why should they not raise the blast to 2,000? Of course, it was easy to build a furnace 180ft. high, and one of their ironmasters did raise a furnace to 103ft. He (Sir Lowthian) demurred to the propriety of that, for this reason, the heating portion of the fuel was considered to be almost exclusively at the tuyers. In point of fact, there was fully 30 per cent. of the heat evolved in the blast furnace evolved at the very top. The conversion of the amount of carbon into carbon dioxide at the top represented 30 per cent. of the heat developed in the blast furnace, but the escaping gases showed no indication of that kind, and for a very simple reason, namely that there was a considerable absorption of heat incurred by splitting up the peroxide of iron into metallic iron and into oxygen. And the question was whether the quantity of heat absorbed by that reaction was greater or less than or equal to that which was generated by the conversion of carbonic oxide into carbonic dioxide. On referring to the books, he found the limit was a very narrow one indeed, that there were not many units difference between the two. Not being satisfied with that, he performed what he considered then, and still considered to be satisfactory and convincing proof that there was a distinct generation of heat. He withdrew from the blast furnace all the iron ore, and he replaced it with material having the same specific heat as iron ore, or thereabout. This substance was of entirely neutral character. No chemical action ensued between them and the reducing gases. The substance he chose was blast-furnace cinder. He found as soon as the iron ore which was then in the furnace had descended to a point where reduction took place the temperature of the escaping gases fell materially. Having continued the furnace for some hours in this condition, he withdrew the slag and renewed the ore, and then immediately the temperature began to rise. That experiment was of importance in this sense, that, having a large quantity of heat and a certain quantity of sensible heat going off at the high part of the furnace, it was perfectly immaterial how high they carried the furnace, because they simply raised the position of the zone of reduction, and the gases would escape at the same temperature from the high furnace as they did from the low furnace. (Applause.)

A brief discussion ensued, in which Dr. Tillden, Professor Roberts-Austen, and others took part.

THE WATER RAILWAY.

Sir Douglas Galton read a paper on the "Chemin de Fer Glissant." He would give them only a short sketch. When he was in Paris he saw this railway at the Exhibition, and he asked M. Barré to furnish him with certain particulars relating to it. He received these only on the previous day, and he thought it would be an interesting matter to bring before the section. He would not be able to do half justice to the full particulars which M. Barré had forwarded to him. The two principles upon which the system was based were—first, carriages sliding on a thin film of water introduced between the sledge plates on which the carriages rest; secondly, propulsion of a sliding train by horizontal columns of water acting through hydrants placed at intervals on the line. The system was originally designed by Girard in 1861, when he made a line at his own private house, where he had an inclination of 1 in 20. The results he obtained he considered justified the application of the system in special cases on a paying basis. He applied for the concession for a railway from Calais to Marseilles. This concession he obtained in 1869, and to this concession a subvention was attached. But the war of 1870 resulted in the destruction by the German army of his model railway, and the death of M. Girard was the result of the war early in 1871. In 1885, M. Barré purchased the drawings left by M. Girard, and introduced an improvement which he considered would make the system more workable. A line on this improved system had been established in the Paris Exhibition. It was about 200 yards long, and on it trains were being actually run. It was in a very out of the way part of the Exhibition, and was somewhat difficult to find out. It simply showed a train running backwards and forwards, and showed none of the means for transferring a train from one line to another, or any of the other arrangements which would be necessary. He would briefly describe the system under the following heads :—First, the sliding arrangement of the skates and the method of supplying water to them; secondly, the rails; thirdly, the propeller and apparatus for putting the train in motion and next he would state a few particulars as to the economy which M. Barré expected would result from the system. The slide was of cast iron. The carriage was supported on a rod, and the water to the skate was supplied through an aperture, coming from cylinders placed in the carriages, where it was maintained at high pressure by means of compressed air, and was carried thus through to the top of the skate, and was pumped into a space, whence it passed out by means of interrupted channels. These channels were so arranged as to break the force of the water and to check it. As the water diminished, the pressure increased, and the slide was raised slightly off the rail to the extent of about half a millimetre. The slide thus rested on a thin film of water. The rails were continuous, and had been made of cast iron with a surface of the width of the skate. In order to keep the skate in position on the line, there was an angle iron attached to the skate on the outer side. There were four or six skates to each carriage, according to the length of the carriage. The propulsion was done by means of hydrants placed at intervals along the line, which opened under the carriages. They were placed in the centre of the line. Each hydrant consisted of a box, which had a valve which, when opened, allowed the water to flow in. There was a piston, and a spiral spring which pressed the piston forward. There was a rod from the piston communicating with the head of the valve, which the spiral spring kept forced forward, so as to close the aperture, the aperture being the mouth of the hydrant where the water finally issued. The water entered a box under a high pressure through a cock, the piston was driven back, and the valve was opened, the diameter of the piston being much smaller than the diameter of the valve. In each carriage was fitted a longitudinally horizontal turbine, or arrangement of veins, and with a pin projecting from it, which caused the cock to open when it approached it, so that, as soon as the carriage approached the hydrant, it was opened, and the water was forced through the aperture, and propelled forward the carriage. As soon as the turbine had been passed, a rod of the carriage closed the cock, and, the water pressure being thus removed from the front of the piston, the valve was closed by the spring. In order to prevent inconvenience from the water used in propulsion, as well as to avoid the large loss of water which would result from this mode of propulsion, there was placed at each hydrant a shield, formed of plates of iron disposed in a parabolic form, and from the upper part of each there was a series of endless chains which hung with their lower parts loose. These chains received the shock of the water after it had passed through the veins of the turbine, and scattered it, and it fell on the line. It was then collected into a conduit and carried back to the pumping engine, which raised it again into the accumulator, to be ready for the next train to pass. The consumption of coal in trains of this sort would be 24 kilogrammes of coal, instead of 420 kilogrammes consumed by the locomotive, thus he would get an economy of 94 per cent. in fuel. Another matter of economy, M. Barré maintained, was in the abolition of the cost of greasing wheels, and the abolition of bearings and tyres and buffers and brakes; and that he reckoned at 66 per cent. as compared with the rolling railway. As an instance of the applicability of this railway, M. Barré said if they had a metallic dock full of water, whose length was 200 metres, width 18 metres, and depth of water 8 metres, and which weighed 44,000 tons with all its mechanism, this would be carried on 432 skates. In regard to frost, M. Barré did not anticipate any difficulty as regarded the supply of water to the skates, because he said the water would be protected in the carriages, and it might, if desired, be mixed with glycerine. A great advantage which M. Barré claimed for the railway was easiness of movement. He also claimed that the carriages could not jump off the rails, but that was a matter of question. The train could be stopped almost immediately, and could be turned on curves. On a level line, a train could be propelled at a speed of 140 miles an hour, with a pressure of 22 kilogrammes in the hydrants.

Sir Frederick J. Bramwell said in 1853 he saw in the United States a parallel attempt to this. It was an attempt to diminish the friction of steamboats in the water by blowing a film of air between the bottom of the boat and the surface of the water. Such a boat made the journey from New Jersey to New York in connexion with one of the ferries for several years. There was no doubt that the boat went with less power applied to the paddles, but it was found that the power required to provide the compressed air was just about equal to what was saved in driving the paddles, and, therefore, the thing was not continued. He thought it was germane to the present subject, as showing that the principle of introducing a film of material between two surfaces was tried a good many years ago. According as the friction of a train on the level was diminished, the more vital it became in deviation from the level. As to the practicability of the scheme, one never knew what would come into use. If any man had predicted what would come of electricity years ago, he would have been called a madman. But electricity had come largely into commercial use. He did not think the elements of commercial use were in this scheme, but he thought it was a very interesting application of science, even if only in an experimental way.

Professor Osborne Reynolds, Manchester, called attention to the danger of the train jumping off the rails. The immense power which they got by the flange in keeping a rolling wheel on the rail was lost.

Sir Douglas Galton, in replying to a question that was put to him, said that in the case of an incline the hydrants would be placed at short intervals. With an incline of 1 in 16, the propelling hydrants would be placed every 7 metres.

ALLOYS.

Professor C. V. C. Unwin, F.R.S., read a paper on "The strength of alloys at apparent temperatures." He said: The strength of the commonly used alloys, such as gun-metal and brass, at moderately high temperatures, is a question of some practical importance. It is well known that iron and copper decrease in tenacity as the temperature is raised, the latter in a very marked degree. There are also experiments showing a still more considerable decrease of tenacity in gun-metal. The author's attention was directed to the matter in studying some experiments made for the Admiralty in 1877. In these experiments copper, Muntz metal, and phosphor bronze showed a tolerably regular decrease of tenacity as the temperature was raised to 500deg. F. But in the case of gun-metal the results were more anomalous. The gun-metals tried were all alloys of copper, tin, and zinc. In the bars tried the tenacity diminished tolerably regularly up to a temperature of 300 deg. or 350 deg. But beyond that temperature there was a sudden decrease of tenacity generally of more than 50 per cent., and at a temperrture of 500 deg. in several cases the tenacity had become *nil*. Now at the high pressures, and correspondingly high temperatures, at which steam-engines are often worked, gun-metal is exposed in many cases to temperatures of 350 deg. or 400 deg. It is practically important to know if at such temperatures its strength is seriously impaired. At any rate, the author found that there were but few experiments on the strength of alloys at different temperatures, and of some of these the trustworthiness was doubtful. Hence it appeared that it might be useful to make some new experiments. In the present experiments the bars to be tested were fixed in an oil-bath heated by a gas-jet. The middle part of the bar for a length of two inches was turned down to a diameter of $\frac{1}{4}$ inch or 5-16th inch. The temperatures were taken by a mercurial thermometer. It is believed that the temperatures are quite accurate except those above 600 deg. Above 600 deg. the thermometer behaved irregularly. The bars were broken in a small special testing-machine of the manometer type, the pressure on the diaphragm being balanced by a mercury column. Rolled bars of yellow brass, Muntz metal, and Delta metal were tried, and the results on these are quite regular. Some bars of cast brass also gave very fairly regular results. The bars of gun-metal gave results of less regularity. This is due, in parts at all events, to the fact that some of the bars cast first proved unsound, and new bars had to be cast to replace them. At some future time the author hopes to try a series of gun-metal bars all cast at the same time. The results were plotted in a diagram, and show that in all cases the decrease of strength follows a regular law, without any such sudden loss of strength as was shown in the Admiralty experiments. Even at temperatures of 600 deg. to 650 deg. all the bars had a not inconsiderable tenacity. The ultimate elongation of the bars in the two-inch test length was measured, and is given in the table. There is a peculiarity in the influence of temperature on the ductility of the bars. In most cases the ultimate elongation diminishes with increase of temperature. With Muntz metal the decrease is regular, and there is still considerable elongation before fracture at a temperature of 650 deg. With yellow brass (rolled) the decrease is more rapid, and there is very little elongation before fracture at temperatures above 500 deg. Cast brass behaves in the same way. The elongations of the gun-metal bars were very irregular, and at temperatures of 600 deg. and upwards the elongation was extremely small. On the other hand, in the case of the Delta metal bars the elongation increased regularly with increase of temperature. The contraction of area was also measured. This follows generally the same law as the elongation at fracture, but the contractions of area are more irregnlar than the elongations.

The President advocated the desirability of investigating the behaviour of alloys both in reference to the periodic law to which Professor Roberts-Austen had called attention, and also to the properties which resulted from various combinations of metals when these metals were in a state of absolute purity. The mixture of alloys had been conducted under a mere rule of thumb. There must be some laws, which investigation would make clear.

RIVER VOLUMES, &c.

A paper by Mr. C. E. de Rance was read, in the absence of the author, on "Records of River Volumes and Flood Levels." The author in his paper said :—The basis of any legislation for the amelioration of floods should be an accurate knowledge of the levels reached by the dry-weather flow, the average flow, and the flood condition of our streams, extending over a long period ; at present such information is rarely obtainable, and, except in waterworks drainage areas, but few observations exist as to the actual volume of water run off daily by the rivers of this country. There can be little doubt that a permanent record of the height of floods, and the volume of the daily flow of our streams, is a matter of national necessity, and that such records could easily be obtained by the County Councils throughout the kingdom. Were gauges painted on the county bridges by the county surveyors, a record could be made at least once a day by the county police on their ordinary rounds. If the feet on the gauges were painted with the actual height above the Ordnance datum, it would facilitate comparison. At important points on large streams automatic recording appliances might be placed under the direct charge of the county surveyor, who at such points might daily ascertain the number of cubic feet of water carried down. Where a river basin extends through two or more counties, the provision for joint action of a "Watershed Board" seems to be already provided for, or suggested, by the Local Government Act of last year. The author hoped the committee of the Section would think the matter of sufficient importance to bring it before the Council, and that they would be inclined to concert such measures as would bring his suggestions, or a modification of them, before the Local Government Board, with the view of their giving the necessary sanction for such observations being carried out by the county officials.

HEATING FROM CENTRAL STATIONS.

In the absence of the author, the Recorder (Mr. Rigg) read a paper by Mr. W. W. Phipson, on "Central Station Heating and Power Supply." The author commenced his paper by commenting upon the growing necessity of a central heating and power supply for cities and large towns, and of the dangers and inconveniences of the present system. He took for his model the scheme in successful operation since 1887, in Boston, U.S., which is known as the Prall System, and exemplified by the Boston Heating Company. This system consists in the constant circulation of water at a high temperature and pressure (viz. at 400 deg. Fahr., and 250 lbs.) on the square inch) from the batteries of boilers at the central station through the supply mains, and back to the boilers by means of the return mains, the circulation being maintained by means of pumps. The ample scope of the system was next entered upon, showing that it was quite adequate to meet all requirements as regards both heat and power. The method of determining the amount of heat or power supplied to the consumer was described. With regard to the loss of heat by radiation, it has been reduced to a minimum by covering the mains with a non-conducting material, reducing the interual temperature of 400 deg. of the pipe to 110 deg. on the outside of the covering. The construction of the pipe trenches, or conduits, was described, together with the sizes of mains, &c. The details of the construction of the mains were fully given, showing that expansion-joints are used, which are fixed at every 100 feet to 150 feet, as well as one where the main changes direction, and of the special connexion used in coupling the pipes together. Service-boxes to supply three houses are fixed under the footpaths, which are connected to the mains by a pipe 1 inch in diameter. From these boxes the house supply is taken by means of copper pipes $\frac{1}{4}$ inch to 1 inch in diameter. At the end of the copper pipe, and inside the house, is fixed a vessel called a "converter," whose use is to permit the water to resolve itself into steam, the pressure of which is controlled by means of a reducing valve fixed on the copper pipe before it enters the converter. From this converter the house services are taken. If a supply of both heat and power is required, double or compound converters are used with two reducing valves, the power being taken from one and the heat from the other. The pumping and boiler capacity of the central station were given, together with the latest additions to ensure economy of labour. The paper concluded with the hope expressed by the author to see a successful central supply of heat and power system adopted in this country, and his thanks to Mr. A. V. Abbot, chief engineer to the Boston Heating Company, for his kind assistance in giving all possible data on the subject.

Sir **FREDERICK BRAMWELL** said the question of the transmission of heating power was becoming more and more important every day. So far as they knew, there were three undoubtedly practical modes of doing it. One was this mode by high-pressure water. The other is the New York mode by steam at comparatively moderate pressure; and the third was the mode with which they were so familiar here—by gas. Whether the electricians in future would give us electricity at so cheap a rate that we could afford it for the purpose of heating, he did not know. It appeared from a newspaper report that one electrician had obtained it with waste water power, and applied it for cooking purposes. But that was an exceptional case, and it seemed to him that they were restricted to these three modes, and it would be a very desirable thing that there should be a paper read before that section which would give in a compendious mode the cost of the installation of a system to deliver heat, another to deliver power, and another to deliver them jointly. As far as he had been able to make out from a paper that was read at the Civil Engineers some few months ago upon the New York system, the provision of steam did not compete favourably with that of gas, at the price at which we obtained it in England, although it competed most favourably with the price prevailing in New York.

AN AUTOMATIC STOKER.

In the absence of the author, a paper by M. Godillot on "An Automatic Stoker" was read. The author claimed that the advantages of the stoker were increased efficiency. poor fuels could be employed equally with the richer kinds, automatic stoking, and complete consumption of smoke.

Sir **FREDERICK BRAMWELL** sketched on the blackboard a furnace which he said was patented a good many years ago, certainly before 1847. It was, he said, used for the purpose of burning anthracite coal. The peculiarity of it was that every one of the fire-bars had a pendant tail, which was immersed in a trough of water. The heat of the fire-bars generated a certain amount of steam. The anthracite coal would not in the ordinary manner produce anything in the nature of a lengthened flame, but the steam was decomposed and recomposed, and a flame of any degree they wished was obtained, and, in addition, the fire-bars were preserved.

The **PRESIDENT**: Water gas, in fact?

Sir **FREDERICK BRAMWELL**: Yes; water gas.

THE HOPCRAFT FURNACE.

The **SECRETARY** (Mr. Conrad W. Cooke) read a paper which had been forwarded on "The Hopcraft Furnace." The author explained the construction of the furnace, and said:—The chief advantages of the furnace are—1. The great saving in the cost of fuel which is effected through burning small coal and coal dust, costing at the pit's mouth from 2s. to 4s. per ton, in place of hard steam or Welsh coal, costing 7s. to 9s. per ton at the pit's mouth. 2. The remarkable latitude in the rate of combustion which this system allows, without the loss in evaporative efficiency, which becomes so serious a matter on an attempt being made to obtain duty from the boiler when the fuel is burned in the ordinary way. Thus 10lbs. to 40lbs. or 50lbs. per square foot of grate per hour may be burned with almost equal advantage. 3. The great saving in labour effected, not a single stoking tool being required while the furnace is at work, the furnace doors not requiring to be opened from one end of the day to the other. 4. The durability of the fire bars, which, owing to their continuous circular movement, wear evenly and regularly. 5. The absence of smoke, even when very bituminous coal is burned in this furnace, and at a rate of combustion which has hitherto been unattempted, even in furnaces fitted with special appliances for smoke consuming. 6. The great saving effected on the grounds of durability. The wear and tear of the boiler flues and tubes is reduced to a minimum, owing to the entire volume of air required for combustion in this system of furnace having to pass through the incandescent fuel on the grate. The air becoming highly and uniformly heated prevents the unequal expansion and contraction which in ordinary methods prove so destructive, owing to the volume of cold air which unavoidably enters the furnace when the doors are opened for firing and cleaning purposes. 7. The remarkable absence of emission of dust and partially consumed carbon at the chimney top, which is so frequently a very serious annoyance common to all furnaces having a good draught, and where coal is thrown on in the ordinary way. (8). The compactness of this patent furnace. The coal hopper, although holding sufficient for from a half to one hour's supply, is not more than breast-high, a most important feature in marine boilers, as the boiler tubes covered by the doors have to be constantly looked at, brushed, &c. The most limited stokehold can be fitted with this furnace without difficulty.

A sub-sectional meeting was held during the day in the lower hall, under the presidency of Lieut.-Col. Alban Cunningham, R.E., A.I.C.E.

A CURVE RANGER.

Mr. **ALEXANDER TROTTER** read a paper on "A Curve Ranger." He said an ordinary five-inch theodolite weighed 12lb. without its case. This instrument weighed 1lb. 10oz., or, with telescope, 2lbs.

AMERICAN AND ENGLISH RAILWAYS.

Mr. E. B. **DORSEY**, M. Am. Soc. C.E., read a paper on the "Comparative Cost of Working English and American Railways." The author exhibited tables comparing the cost of operating expenses in 1888 on the London and North-Western, Great Northern, Midland, Great Western, Great Eastern, and North-Eastern railways of England with those on the Pennsylvania railroad and the Knoxville branch of the Louisville and Nashville system, these two last-named roads representing the extreme types of American railway construction—the first being one of the best, and the last one of the most cheaply constructed roads in America. It was shown that on the English railways, which have cost from four to six times more to construct than the American roads, the cost for transporting freight is more than double the American cost, whereas it should be less, or why make the increased outlay for superior construction? The author also described experiments made with a dynamometer showing the comparative power required to transport goods in the American and English railway car or waggon—the results being greatly in favour of the American car; they account largely for the cheaper operating expenses of the American railways. The author thinks that the great difference in favour of American railways in the working expenses is owing principally to the following reasons:—1st The trains on the American railways carry much larger loads than those on the English road. 2nd. The universal use on the American railways of rolling stock with bogie trucks, which run with much less friction and wear and tear than the English rolling stock with its long rigid wheel base. 3rd. The general use on the American railways of freight cars or waggons, carrying a greater percentage of paying load to dead weight than those used on the English railways. 4th. The lower speed at which the American goods trains run. 5th. The use on the American railways of heavier locomotives, which haul heavier loads than can be done by the lighter ones used on the English railways. 6th. The use of locomotives on the American railways with outside cylinders and connexions, which can be more cheaply and easily repaired than those with inside cylinders, used on the English railways. 7th. The use on the American railways of collecting and distributing goods trains, which load and unload at the stations goods in less than car-load quantities, thus avoiding the use of waggons only partially loaded, as is the custom on the English railways; the Americans apply to their goods trains the same principle that the English railway managers now apply to their milk-trains.

THE DEEPENING OF RIVERS.

A paper by Mr. W. H. Wheeler, on "The Application of the Transporting Power of Water to the deepening and improvement of Rivers," was taken as read. The object of this paper is to show :—(1) That the transporting power of water may be economically applied to the deepening and improvement of rivers. (2) That under favourable conditions this can be accomplished by breaking up shoals, or the natural bed of a river, by mechanical agency, and by mixing the material with the water and allowing it to be carried away to the sea or estuary in suspension. The successful application of the process depends on the complete disintegration of the material and the thorough mixing of the particles so disintegrated with the water by continuous stirring or churning, and so reducing it to the condition in which alluvial matter is transported by rivers when in a turbid condition. It is shown by the paper that all rivers carry during seasons of flood large quantities of matter in suspension, and it is contended that what is thus done naturally may be imitated artificially, and the rivers made the agents for their own improvement. The disintegrating and mixing process which is effected by frosts and rains on the alluvial matter which is carried away to sea may be applied to the bed of a river, or shoals, by mechanical agency, and the material thus broken up be transported away by the current. The erosive and transporting power of water is dealt with, and examples quoted of the enormous amount of alluvial matter transported by some of the larger rivers. Instances are quoted to show that the quantity transported amounts to as much in some cases as 2lbs. of solid matter in every cubic foot of water, or 1-32nd of the whole weight. Examples are given to show that a current of 3 feet per second is sufficient to carry away material broken up from the bed of a river and mixed with the water in the form of mud at the rate of 11·8 tons in 24 hours in every cubic foot of water; the transporting power being equal to 1-600th of the whole mass of water in motion. The power of water to transport material of much greater specific gravity than itself is shown to be due to the ever-varying motion of the particles of water as they move along the channel, the numerous whirlpools and eddies caused by irregularities in the contour of the channel giving a rotary and upward motion which prevent the particles of matter in suspension from being deposited. The power of water to transport solid material depends on the velocity which governs the transporting power in two ways: one certain, when, the quantity of water being constant, the amount of material carried will vary directly as the velocity, and as affected by the time that gravity has to act on the particles while travelling a given distance; the other uncertain, and being due to the increase of eddies and whirling motions set up by the increased momentum of the stream. Also depending on the fineness of the particles and the specific gravity of the material in suspension. A table is given showing the result of experiments on the weight of different kinds of clay, sand, and warp; the time taken to deposit in water; and the quantity transported by a stream of water running at the rate of one foot per second. The second part of the paper deals with the practical application of the process, and several instances are quoted of its successful adoption. The processes described are harrowing; scouring caused by the use of artificial dams attached to barges; forcing water and air into shoals and sand-beds by pumps worked by steam power; also pumping up the material and delivering on to the surface of the ebbing current; and breaking up beds of clay by means of revolving rollers drawn along the bed of the stream. The process has been successfully applied to the deepening of rivers in the Fen District, at a cost very considerably under that by which the improvement could have been effected by the ordinary method of dredging; and at Tilbury Dock the cleansing of the tidal basin is now carried out at one-fortieth of the cost that used to be incurred in removing the deposit by dredging. As the successful application of the process depends on the thorough disintegration of the particles to be moved by continual stirring or churning, the author has, after numerous trials, designed an improvement on existing machines, which, while breaking up and disintegrating shoals composed of clay, sand, or warp, at the same time thoroughly mixes the material with the water, allowing it to be effectively transported by the ebb current clear of the channel to be improved.

DRAUGHT FOR VEHICLES.

Mr. T. H. Brigg, Bradford, read a paper on "The Theory of Draught for Vehicles and a New Arrangement for Traction." The first part of Mr. Brigg's paper was designed to show that, and in what way, the method of ascertaining the correct line of draught or trace by which to attach horses to vehicles in common use is altogether fallacious, that the present method of attachment is bad, robbing the horse of much of its power, imposing upon the animal unnecessary work, and placing him at a serious disadvantage, especially in going up or down hill or upon a rough road. Indeed, in accordance with the obstacles to be overcome by the wheels, either on the level or on an incline, the correct line of draught is, the writer contended, ever varying and never constant. His contention was that the horse as at present attached to his load was caused to exert an unreasonable amount of force from his hind quarters, particularly when in heavy draught. By the present method of attachment all the weight of the horse, *plus* the increase of weight due to inclination of trace, was thrown upon the animal's hind legs, thus causing him to tire much sooner than he would were the method of attachment such as to distribute the weight equally over the whole of the animal's body. The paper was illustrated by numerous diagrams, with the aid of which the writer demonstrated the fallacies which are at present generally held upon the subject. Incidentally, he quoted Professor W. C. Urwin, C.E., who had found that, supposing a horse to weigh 12 cwt.—6 cwt. in the fore and 6 cwt. in the hind quarters, the effect of a horizontal pull of 5 cwt. was to reduce the forward weight to 2·7 cwt., and to increase the weight on the hind legs to 9·3 cwts., whereas with an inclination of trace equal to 30 degrees the horse retained 5·1 cwt. on the fore legs, and 9·1 cwt. on the hind legs—an increased weight of 2·2 cwt., due to the inclination of the trace; thus proving that horses effecting their draught under ordinary circumstance are doing the bulk of their work with their hind legs, instead of having it equally distributed. He explained the principle of his invention for so attaching a horse to a vehicle that whatever may be the pull exerted by the horse through the trace, the animal retains at all times his natural weight in the fore quarters. The trace ordinarily pulls all, or nearly all the weight on to the hind legs, and thus robs the horse of his forward weight, and the tractive force of those quarters. By this application, however, there is a vertical thrust upon the fore-quarters equal to and counteracting the lifting tendency of the trace, or, if necessary, there may be a slightly increased weight to correspond with the increase of weight on the hind legs due to the resolved inclination or line of draught. Thus the work done is proportionately distributed upon all four legs. This is accomplished by a very simple arrangement of levers, by which is automatically obtained the most economical and ever-varying angle of draught, and a consequent effect on the horse. The combination of levers can be so actuated by the driver that when the horse is travelling down hill he can relieve it of part of its weight, and thus destroy the evil effects of percussion at his fore feet and legs, which, to his mind, was just as hurtful as climbing hills. Mr. Brigg said he had no hesitation in saying, even before an audience of thoroughly scientific gentlemen, that a saving of at least 50 per cent, in horse flesh alone was effected by the use of the attachment. He thought that in no one instance had there been a more extravagant waste of natural forces than in the matter of draught. Besides that, in proportion to the loss sustained, so has been the pain and misery inflicted on the noblest, most useful, and most faithful of animals. The profound and unjustifiable ignorance which prevails upon this important question could not possibly have existed had due consideration been devoted to it by scientists. In conclusion, the author dealt with the question of difference of draught between a long and a short coupled vehicle, between a large and small front wheel in four-wheeled vehicles, and the distribution of weight on the small and large wheels. Many of our large coachbuilders and engineers, and even professors of engineering, he said, went so far as to say that there is no difference of draught between long and short-coupled vehicles, and our horses are thus continually made to suffer the penalty due to our ignorance upon the matter. By the aid of diagrams Mr. Brigg showed that a small front wheel was preferable to a large one, providing that the attachment of the trace be to the centre of the axle in both cases. In the event of the force of momentum being exerted upon the fore wheels of a vehicle, it would be found that a large front wheel was the preferable form, but, in climbing, the force of momentum was practically *nil*, and small wheels were undoubtedly the best; while obstacles will be passed over more easily by a short-coupled vehicle.

SECTION H.—ANTHROPOLOGY.

THE ESQUIMAUX.

Dr. **Fridtjof Nansen** delivered a lecture on "The Esquimaux," and in the course of his remarks said his discourse would consist of remarks upon the customs and life of the Esquimaux. He was no anthropologist, and therefore dared not take up the scientific part of the subject. The Esquimaux were a race in themselves, and he did not think anthropologists agreed as to their real origin. They were distributed along the north coast of America, a small part of Asia, and along the whole coast of Greenland. The origin of the Esquimaux anthropologists divided into two classes. Some maintained that they were related to the Japanese or some of the Arctic tribes of the Asiatic population. Others maintained that the Esquimaux originated from the Indian of America. That was first maintained by Dr. Pink, who was the first authority to contend that the Esquimaux were the weaker Indians who were driven north by the stronger Indians, and that as they were driven north they began to live more upon the sea than upon the land. The first boats they built were birch canoes, and, as they went further north, they could not get birch, and so they were compelled to make their boats of skins. He had not examined skulls and anatomies of the Esquimaux, and he did not think they had been examined enough as yet to any great certainty. From where these people came they could not tell, but he knew the way they came, and also knew of their wanderings. There was no doubt that the Esquimaux came across the north coast of America, across the hills to Greenland. If they looked at the tales of the Norsemen, they would find it mentioned that they found ruins and huts there, and he thought that was evidence that they had existence before the Norsemen came, but they really did not know when they came to Greenland. There were some tales and superstitions amongst the Esquimaux, and one of their tales was that there lived in the interior of Greenland—which was covered with seven thousand feet of ice and snow, and therefore uninhabitable—a people who were 9, 10, or 12 feet high, and that they sometimes came to the shores of Greenland and carried inland the largest of the seals. He thought that the tale originated with the Indians, and that it coincided with the idea that the Esquimaux were descended from the Indians who had been driven to the coast. When they spoke of the "interior," they spoke of the tales handed down to them of the people going into the "interior" of America with spoil. (Applause.) The Esquimaux were divided into two classes or lines. On the west coast, the Esquimaux were now somewhat civilised by the Danes, but on the east coast they were not civilised. When he first met with the Esquimaux, he found them on a part of the coast he did not expect to find them, or indeed any people. The place was quite bare and wild, where no human beings could really exist. It was a party they met, passing the place from the south. As he told them in his paper yesterday, the Esquimaux sometimes took four years to do their shopping. (Laughter.) They sometimes took two years to get to the shop, and, after being inside the shop for about half an hour, they took two years to get back home again. (Laughter.) They bought tin, snuff, &c., and they gave in exchange polar bear skins, seal skins, and other things of value. The dress of the Esquimaux was, he thought, a very good and nice one. He had with him the dress of a woman from the west coast of Greenland, and it was similar to those worn by the Esquimaux tribes. (Dr. Nansen here produced the articles of clothing.) The boots were made of seal skin. Those he exhibited were women's boots, which reached above the knees. The inside of the boots was covered with fur, which was worn next the skin, as the ladies there did not wear stockings. (Laughter.) The boots were very warm. They were tied to the upper dress, but the Esquimaux did not tie usually. The embroidery on the boots was not artistic. The ladies' trousers, they would observe, were very short—(loud laughter)—being a foot and a half deep. They wore their trousers night and day, and never took them off. (Renewed laughter.) The jacket was also very attractive. They had a close collar, and they wore dog skin on the wrists and neck. The jacket was very short, and there was a strip exposed between the jacket and the trousers. This was to show the white linen shirt. They were very proud of the white linen. When they first got the linen they thought it was so very nice that they had to show the men that they had some—(laughter)—and so they exposed some of it between the trousers and the jacket. (Laughter.) The eastern Esquimaux had warmer clothes than the western Esquimaux, where many of them had nothing on a portion of the leg. The young girls wore their hair loose, and it was tied up into a high knot to show that they were ready for marriage. (Laughter.) The Esquimaux lived as a rule in small tribes, but on the east coast, in the winter, they lived in large huts, where a large number of families lived together. As a rule they had only one house in a place or village, and they would find ten or twelve families in one hut—sometimes a hundred people living under one roof. The huts were very long and very low, and were to some extent underground. In order to get inside one had to creep along a narrow passage on hands and knees. He remembered hearing of a big European trying to get into a hut and sticking in the middle of it. (Laughter.) He could neither go backwards nor forwards. Two boys were got, one in front and the other behind, to get him along. (Laughter.) After a great deal of difficulty, they managed to get him inside, where the men, who are, comparatively speaking, thin, nearly exploded at the sight of so big a person. (Laughter.) As soon as spring came, the people left their huts and went into tents. That was a very wholesome thing for Esquimaux. The roofs of the huts were broken down to let fresh air into the place.—In answer to a question here asked, Dr. Nansen said the huts were made of drift wood. Continuing, he said it was to be regretted that the Danes on the west coast had made them live in smaller huts. By this means they were separated, and that was bad for the Esquimaux, as sometimes families did not get a sufficient number of seals to provide them oil enough to keep their huts warm, and so they suffered very much from the cold. The boats of the Esquimaux were of two kinds—one used by the women, and the other used by the men. It was thought undignified for a man to pull a woman's boat. It was quite astonishing to see the speed the men could go at in their kyaks or boats. They could go eighty miles a day. He had seen them go into the sea, and had seen the waves dashing over them, burying them for a moment. But the men seemed to revel in it, and laughed at the storms. The Esquimaux had no written laws, but they had laws which were kept as strictly as the laws were kept here. The first law for the Esquimaux was to help others. (Applause.) In that respect they were the best people he had ever travelled amongst. The head of the house was the best "catcher," that is one who caught seals well. This was considered the cleverest and best thing to do in Greenland—to get as many seals as possible. He who could do this best was the best man. As long as a man could catch seals well, there was no doubt about his superiority. If he grew old, and could not catch seals, he was put aside, unless he had children who could catch well, and then he was allowed to remain at the head of the house. As to property, they really did not know the word. (Applause.) The property of the Esquimau consisted of his weapons and his kyak. Even the houses and women's boats did not belong to any special men—they belonged to the families. An Esquimau had not anything for himself. When he went home with seals they were taken, of course, to his family, and what was left over was divided between the other families; in fact, they all got just as much as the catcher himself got. The Danes on the West Coast had tried to change this. They had tried to make the Esquimaux understand the necessity of property. He thought that was very bad. It was necessary for the Esquimaux not to have any property. He had already pointed out that, when a man caught seals, he divided them. If he did not, he would eat it all himself, because the men could not bear to see food without eating it—(laughter)—he ate as long as he could open his mouth. (Laughter.) The food was divided, and all the families got it, and the next day another man caught seals, and again they were divided. The Esquimaux thought Europeans very greedy and bad because they did not like to give away very much. They thought themselves very good and kind, and Europeans very bad. They could not understand Christianity, when they tried to import it into Greenland. When the missionaries spoke of punishment after death, they said, "Well, we quite understand you ought to be punished after death, but hell was not made for us." (Loud laughter.) Stealing amongst themselves was considered very bad, but stealing from other people was not thought anything of. (Laughter.) They would steal from Europeans if they got the chance, and he thought that was because they were treated so badly by Europeans when they first came across them. The influence of Europeans on these people had in this respect been very bad. Amongst the first European visitors must have been a number of thieves and rascals, for the people spoke of them still. Murder was not uncommon amongst them, on the east coast, and they knew of a great many instances of murder. The reasons for murders were sometimes very trivial—it might be that one man was a better catcher than another, and one who was jealous killed him. In other cases women were the reasons. Murder also took place on the west coast. The punishment for murder was very little—in fact, there was no punishment for it. He remembered on the west coast a man had killed his mother, and the chief of the house gave him some weapons and a new boat, and told him to go and live on an island. For a time the murderer lived there, but he shortly after returned, saying that he could not live there, as there was no game. The man settled down amongst the people again, and the only punishment he had received was the gift of weapons and a new boat for killing his mother. (Laughter,) When a man fell in love with a woman, he did not go and pour passionate utterances into her ear—(laughter)—he simply took her by the hair of the head, and dragged or pulled her to his hut. (Loud laughter.) Of course a woman in Greenland must, as in all other places, pretend not to like it. (Loud laughter.) The women were not considered well educated if they did not run back home two or three times after being dragged away. (Laughter) If they ran away too often the men did not like it. (Laughter.) Dr. Nansen then related the case of a man going over and over again to drag the girl of his choice to his hut, but she always ran back. He desisted for some time, and again tried. The girl's friends saw him in the distance, and they protected her at her request. He went away without her and the next day she was missing—she had gone to comfort her broken-hearted lover. (Laughter.) The husband's labour was on the sea, and after the game was caught the women looked after it. The men in the house were, as a rule, very lazy; they did nothing but eat and look after their weapons. The women were always working—either sewing, spinning, making clothes, or busy in household work. They looked well after their children, of whom they were very fond. The men, as a rule, married early—as soon as they could catch seals enough to provide for a wife and family. The reasons they gave for marrying were to have the skins of the seals attended to and to keep their clothes in order—of course there were other reasons. (Laughter.) Very often husband and wife separated, and this they did without any ceremony. Cases were known in which men as well as women had been married six or eight times. They seemed to consider their wives more as property than as wives—that was one of the very few cases in which the Esquimaux had property. (Laughter.) When the men married again, if a man liked his new wife he kept her, but if not he passed her on. (Laughter.) When children were born, a more solid relationship was established between wife and husband. Quarrelling between husbands and wives was not uncommon. (Laughter.) Sometimes the women got their husbands' knives into their arms or legs, but afterwards the relationship seemed to be just as good as before. (Laughter.) Cousins never married, and second cousins tried to avoid it. They tried, if possible, to get wives from other parts of the country. In this respect the Esquimaux were more fortunate than the Norwegians were. The peasants there thought it very proper to marry their cousins, especially when they had money—(laughter) because they said the money ought not to go out of the family. (Laughter) It very often happened that good catchers on the east coast had two wives; cases of more than two wives were not known. The reason given for more than one wife was that one wife could not prepare the skins of the seals caught, and also that two women had to be used to pull the boat. Sometimes one wife, when she could not manage the work and the house, asked her husband to take another wife. (Laughter.) Husband and wife did not kiss, but saluted by pressing noses. (Laughter.) Parents never punished their children, and he never heard an Esquimau speak angrily to his children. In spite of this, the youngsters behaved very well. A mother suckled her child two years. He had seen a strapping little fellow eating bread, standing by his mother's lap, and taking fluid from the maternal fount. (Laughter.) Young girls very often got small knives and learnt how to prepare skins. This was very important to the young women, as they had to manage the cutting of the skins. The young boys were also taught to catch seals. There were, of course, weak children, deformed ones, and those who lost their mothers. These were usually thrown outside the house or into the sea. This was, of course, a very good arrangement—(laughter)—but rather cruel from their point of view. This practice was indulged in in order to get as strong boys and children as possible. Hospitality in Greenland was greater than anywhere else. A visitor might stay as long as he liked, and he would always be well treated. The food consisted principally of salt meat, and a great deal of it was eaten raw. They ate the intestines, and they ate the liver raw, which was much relished. They also ate certain kinds of grass of a special kind. On the west coast the customs of the people changed to some degree. Civilisation had made them more civilised, of course. Were he asked what civilisation had done for them, he would reply "Nothing." It had brought them tobacco, coffee, and tea, which were really of no use to them, and to a great extent spoiled them. He thought he heard a great many of them say they had brought them Christianity. It might be, but he did not think that was any good to the Esquimaux. He thought they were worse than before in regard to morality. He asked whether it was better for a man who was a Christian and who followed its doctrines to bring children into the world into misery and poverty and be unhappy, or not to be a Christian and be content—a good catcher, and who could easily provide for himself and children. (Applause.) The Danes and Europeans had been very anxious to make the Esquimaux Christians, and to bring them to Christian morality. With the Esquimaux the best man in society was strongest, and he who could catch the most seals was the best servant for the Europeans and Danes. With their contact with the Europeans the people were becoming weaker, and they on the west coast were not such good catchers as those on the east coast. With regard to Christianising the east coast, he warned missionaries that he did not think it would be much good to the people. They would be slaves as long as they lived. They were dreadfully superstitious. The present Europeans in Greenland really lived as parasites on the Esquimaux. They did not bring them any good, they only took "goods" from them. (Hear, hear.) He thought the day would come when Greenland would become desolate, and when the Esquimaux would become extinct. (Loud and continued applause.)

Prof. Turner said it was quite evident from the applause that had greeted Dr. Nansen that they were prepared to accord him a hearty vote of thanks for his extremely interesting account of the Esquimaux. He need scarcely refer to the humorous and epigrammatic way in which he had touched off the most salient features of the points in the character of these people, and they must feel also how admirably Dr. Nansen had expressed himself in a foreign tongue. (Loud applause.) They had already in that section an interesting paper and discussion as to whether the Vikings were the origin of the English-speaking people. Now, they had got a magnificent specimen of the Viking with them that day—(laughter and applause)—and for the admirable manner in which he had discoursed in the English language he thought he was an example of how the Vikings are an English-speaking people. (Laughter and applause.)

Dr. Morton Middleton, of Tennessee; Dr. Reay, a celebrated Arctic traveller; Mr. Hoyle, and Surgeon-Major Ince also spoke on the Esquimaux.

Prof. Turner said he had examined some crania from the east of Greenland, and it seemed to him that, after making comparisons, there would seem to have been a migration from the west, for the crania on the west coast were different from those on the east coast.

In answer to a question, Dr. Nansen said the Esquimaux did take snuff—that he had seen a man with a very large horn of snuff. Every five minutes he helped himself, and when he sneezed he was almost upset out of his kyak. (Laughter.)

NORTHUMBERLAND IN PREHISTORIC TIMES.

The Rev. G. Rome Hall, F.S.A., vicar of Birtley, hon. local secretary for Northumberland of the Society of Antiquaries, London, read a paper on this subject. He said:—Archæology, which has to do with that which is ancient in the widest sense, is an important branch of the new and advancing science of anthropology, which relates to man in his every aspect and in all times and places. Prehistoric archæology takes cognisance of man in his very earliest conditions before the dawn of recorded history. It is the connecting and binding link between geology and historical times. My own first acquaintance with the prehistoric remains of this country was when I first came to my present parish of Birtley, in North Tynedale, about twenty-eight years since. Sheltering from a driving shower on the lonely hill-side, under the lee of a high stone wall and an umbrella, I saw, in looking around, what seemed to be the foundations of

CIRCULAR DWELLINGS,

such as Livingstone describes in South Africa. He says he tried to induce his people to build their houses "on the square," as we do, but as soon as his back was turned they reverted to the accustomed mode. Around these ancient dwellings were a ditch and defensive mounds. This "Carry House" Camp — the "caer," as in Carlisle, refers probably to the Celtic town itself — was one of the many ancient British villages fortified, like a Maori pah in New Zealand, with similar strong palisades fixed upon the rampart encircling it, as Cæsar describes those in the south of England in his days. My sheltering wall was a dividing fence between two ancient farm holdings, thus testifying to the camp being a landmark of old. The circular habitations were from fifteen to twenty-four feet in diameter, having a low perpendicular wall of wattled work, the roof formed of young saplings brought together at the top in conical shape, like our hay and corn stacks —daubed outside with clay, and covered on the summit with sods or turf—having sometimes a partition, thus making, as I found in this camp, two chambers, or else a kind of raised couch. This I found after excavations in the hut-circles by permission of the Duke of Northumberland, the landowner. Our work was regarded by the discovery of many interesting relics of the latest prehistoric period, passing, as we judged, from faint indications into the times of the Roman Conquest and occupation.

A LATE CELTIC SWORD.

Among other things I found lying broken in the interstices of the rude flagging of the chief dwelling a much corroded long sword of iron, first thought to be a Saxon Thane's, but afterwards decided by Mr. Franks, of the British Museum, to be Late-Keltic. Its blunt point was still sheathed in the rounded point of the bronze-tipped scabbard, and it was probably very like those described by Tacitus as used by the Caledonians at the battle of the Grampians. Their swords were of iron, but so ill tempered that they bent at every stroke; and so it was no wonder that the well-armed legionaries of Agricola, with whose advance the prehistoric times in Northumberland end about A.D. 180, won the victory.

ANCIENT BRITISH RELICS.

One of the rarest "finds" here in this hut circle was a broken buckle of bronze from the horse trapping of an ancient British chariot, laid on a flagstone near the much corroded sword. There was also, in a "made" cavity under the central slab, a bundle of spear heads, daggers, and knives of iron. These relics are in the Alnwick Castle Museum, and a full description in the London *Archæologia*. It was suggested to me, a little time ago, that a paper on "Northumberland in Prehistoric Times" might possess some interest for the members of the British Association now met together in its chief town—in particular for those connected with the Anthropological Section. It is very difficult, however, to condense into a few minutes any conspectus of what we now know of this county before the Romans crossed the Derwent and the Tyne. Nevertheless, it may be worth the trial; and if there should be failure, it is not for want of material. Especially may I be permitted the honour of presenting at least a hasty sketch before you, as at the last or second meeting of the British Association here in 1863 I brought forward notes of a survey of ancient British remains observed, many of them for the first time, in the valleys of the rivers North Tyne and Rede. Since then numerous discoveries of much interest have been made by competent explorers, such as the Rev. Wm. Greenwell, Messrs. Hardy, D. D. Dixon, and others, which have been recorded in that valuable work, Mr. Greenwell's "British Barrows," the *Archæologia Æliana*, transactions of the Natural History Society of Durham and Northumberland, and Tyneside Naturalists' Field Club, the Berwickshire Field Club, and other archæological and scientific publications. My remarks do not refer to the old historic Northumbria, the land north of the river Humber, far-reaching then to the Firth of Forth, but only to this modern Northumberland, which has so dwindled in area that it is now two counties distant from the Humber, a mere fraction of the great Anglian kingdom of the Bretwaldas—greatly lessened in its extent in the course of centuries; like Lotharingia, the wide realm of Lothair, now diminished to the present small province of Lorraine in Germany; or the Land of Israel, first synonymous with David's extensive kingdom, but after his son Solomon's days referring only to the northern part of the Holy Land, west of Jordan. Within the bounds of ancient Northumbria, the Victoria Cave, near Settle, in Yorkshire, has made us familiar, in the times when Britain was joined on to the Continent of Europe, with the handiwork of palæolithic man of the Old Stone Age—interglacial or even, as some would say, pre-glacial. It has been well described by Professor Boyd Dawkins; as Mr. Pengelly has with infinite care and zeal done for the great bone cavern of Torquay—Kent's Hole—which I have recently had the advantage of seeing, with the remains of the mammoth, true British lion, no longer a heraldic myth, the woolly-haired rhinoceros, and other extinct carnivora—the contemporaries of the troglodytes of the Devon and Yorkshire cave-habitations. So far as Northumberland is concerned, we have never as yet found a trace of the men of the oldest stone period of rudely chipped implements and weapons. In Norfolk we find their nearest home and vestiges, so far as I know.

THE NEOLITHIC PERIOD.

After an immense lapse of ages, following Sir John Lubbock's division, we pass to the Neolithic times, when man first leaves some proofs of his existence in this country, in numerous polished stone implements. Not all his, however, for the three ages suggested by the Danish antiquaries overlapped each other—stone being in use in the Bronze age, and bronze in the Iron age. These Neolithic people, the earliest inhabitants of Europe, Britain, and Northumberland, must have appeared many thousands of years since; but here we cannot speak with any definiteness. They were immensely superior to the Paleolithic men—had, as a race, "long heads" (not mentally, but physically speaking), and therefore are called the "dolichocephalic people, of whom no representative has as yet been disinterred in Northumberland or Durham from any 'long-barrow." Nevertheless they must have been here, from the great number of polished stone axes, celts, and other weapons and implements discovered at various times. They were of low stature, dark complexion, and had dark eyes, such men as the Iberian survivals in Wales and Ireland whom we still meet with. They had a kind of civilisation, had domesticated animals, like the *bos longifrons*, the small cattle yet found in Wales and the Highlands of Scotland. The Chillingham wild cattle are of much later date, brought in by the Saxons—dark coloured shorthorns. They cultivated some plants and seeds; knew some of the arts, as weaving. They practised inhumation, burying the body doubled up as in sleep in stone-lined graves. They had pleasing features, and were of a gentle disposition; and are supposed to be of the same Turanian stock as the Basques of Spain and the Lapps and Finns. Ignorant of all metals, it is thought, except, perhaps, of gold. Gold beads have been taken from a cairn at Chesterhope of the Bronze age, and a gold amulet found near Bellingham passed into the melting pot. Professor Rhys supposes that "Druidism originated with the non-Aryan, non-Celtic people." The superstitious respect paid to fairies, elves, and the "little people," still met with on our Anglo-Scottish borders, is not improbably a survival of the Neolithic worship of ancestors—one of the oldest religions, like sun and element worship. At this time and till after the Christian era the dense, illimitable forests spread over nearly the whole land, especially in the river-valleys, in which roamed various species of wild animals, the red and other deer, the brown bear, wolf, wild-boar, reindeer, and others; objects of the chase to the Neolithic hunters and those of later times. The climate was colder in winter and warmer in summer on account of the great extent of forest land, and there would be far more rainfall, as was the case even to the Norman Conquest, when the impenetrable Forest of Lowes, north of the Roman Wall, and others were burnt, as they were also by the Romans, to prevent, if possible, the vanquished fugitives from finding refuge. The contour of hill and valley in prehistoric times would be much the same as we see it at the present day; and as it has been since the glacial period passed away. The stone age has its modern representatives until the European settlement of America in the Red Indians, very nearly in the aborigines of Australia and other savage races. Within memory in Northumberland bullocks have been killed with a stone hatchet and sheep flayed with a flint knife. After an interval, we know not of how long duration, but probably about B.C. 1000, in our country there came an invading race; using weapons of bronze, taller, fiercer-looking, having high cheek-bones, fair hair, and blue eyes.

THE BRONZE AGE.

Being better armed they soon conquered the aborigines, probably intermarrying with them, as we find a puzzling circumstance in second "Long Heads" cropping out in later times, as in a burial cist near the Barrasford whinstone quarries in North Tynedale. One result of the mingling of the two races, the stone-using black-eyed "Long Heads," and these new invaders, the bronze-using blue-eyed "brachy-cephalic" or round-headed people, is said to be shown now in their very distant descendants, the brown-eyed friends who are so much admired by many in our days. These invaders were the first wave of the Aryan or Indo-Germanic migration from the far East, I venture to think, though Canon Taylor has some reasons to give for an original home near the Baltic. Nearly all the barrows opened in Northumberland belong to this age of bronze, Mr. Greenwell thinks, and from my own experience I am glad to coincide in this opinion. Sharp cutting and thrusting swords, axes, chisels, and other weapons of war and instruments of peace of this period and from this country are found in profusion in our public museums and private collections, especially in that of Mr. Greenwell, of Durham. These first "round-heads" are considered to have been of the Gadhelic or Gaelic branch of the Celtic race, who were, in their turn, conquered and driven back westward into the Isle of Man and Ireland, and northward into the Highlands of Scotland, by the Brithons, whom the Saxons called "Welsh," or strangers, thus adding insult to injury. These Cymric people of the latter migration from the far East resembled their predecessors in Northumberland. We seem to have a trace of their landing at Holy Island and retreat westward across this narrow part of our island in the Irish name "lough" for lake, only used in this county and near Carlisle; also in "ros," the Gadhelic test-word, for a prominent headland; in Mill-*knock*, near Birtley; in the name of the river Tyne; *don, dan, utain*, water, and others. These earliest Celts are supposed to have brought in cremation, of which burning of the dead we find a trace in our burial service, which speaks of "Earth to earth, *ashes to ashes*, dust to dust." The reason for the conquest of the first branch of the Celts by the second, was thier possession of iron weapons, such as I have described as found in the Carry House "camp" near Birtley. In the Gunnar Peak Camp, on the great crags of columnar basalt in North Tynedale, a fine position, where I was enabled to dig into the dwellings through the liberality of the present Duke of Northumberland, we found iron rings and other objects, with fragments of British pottery ornamented with finger-tip impressions, similar to the fictile ware, cinerary, "food-vessel," and "drinking-cup" urns in prehistoric barrows throughout the county. Unlike the result of explorations in the triple fort at Greaves Ash—the largest Ancient British stronghold in Northumberland—we met with undoubted traces of intercourse with Roman civilization. There were in the Gunner Camp (only one of several in the Barrasford Crags) two rectangular as well as circular dwellings. Gallic huts of both forms are represented on the Antonian Column at Rome. In the smaller, square building, probably of somewhat later date than the rest, we discovered, and rescued out of a lump of clayey soil, a beautiful harp-shaped fibula or brooch of bronze, with safety pin attached, in such an excellent condition that any of my fair auditors might not have disdained to use it. This and fragments of Samian and Amphor pottery showed us that the end had now been reached of prehistoric times in Northumberland. Imperial Rome had laid its mighty, far-reaching hand upon the neck of Britannia, and she was no longer free, but a vassal tributary of the Eternal City.

MONEY HILL.

A fortnight ago I saw near Merivale Bridge, in Dartmoor, a plateau of moorland covered with prehistoric remains; a "Druid" circle, so-called; cists, hut circles, a fallen dolmen or stone-table, the largest menhir or standing-stone on Dartmoor; and two long, double avenues of stones. On Harter Brook, below Prince Town, I visited cairns, a double avenue of stones, and a well-preserved Ancient British ramparted village, with numerous hut circles within the enclosure. All except these avenues of stones I could show in many parts of this country to any visitor, who would find them exceedingly similar to pre-Roman remains in Devonshire. Our finest monolith is near Swinburn Castle, 11ft. in height, in which are three of those myterious cup-markings noticed first in rocks close to British camps near Doddington and Old Berwick, in Northumberland, since discovered in prehistoric stone monuments from Argyleshire to Cornwall. Mr. Rivett-Carnac has found their analogues in India on rocks devoted to "Mahadeo" worship, that is—of the reproductive powers of nature. These archaic sculpturings of cups and concentric circles are met with on the slabs forming cists or stone-lined graves. The Lord Bishop of Newcastle, Dr. Hodgkin, and myself found fifteen stones with cups upon them in the great burial mound, or family barrow, at Pitland Hills, near Birtley. The most interesting earthwork which we possess is the Money Hill at Gunnarton, about 50 feet high, conical, with surrounding and flanking ramparts and ditches. A dragon is supposed to be keeping watch and ward over a buried treasure, deep within the great "how"—a Norse Saga legend. Hence the name of Money Hill. But, after digging on the second occasion far below the natural level, I neither saw any dragon-watcher nor found any hidden riches. Though we have several good examples of the lines of terrace-cultivation for the limited growth of corn by the ancient Britons, probably the most striking and complete is that near Birtley, which rises tier above tier, with the north-west face 500 yards long and the south-east face 110 yards in length. There are very numerous camps, tumuli, cists, and other remains, shown in MacLauchlan's map, published with Dr. Collingwood Bruce's excellent *Lapidarium Septentrionale*, many well worthy of a visit. Canoes of split oak trees dug out have been found in the silt of the Tyne for travel and fishery, and a paddle near Tweeedmouth like a South Sea Islander's. Much more I might have said in describing "Northumberland in pre-historic times." Time will not admit of a fuller treatment *vivâ voce*, though it has been written in extended form. Sufficient, perhaps, has been adduced to be of some little interest to those members of the British Association who have not the advantage and happiness to be, like some of us, Northumbrians by birth or residence. Those of my auditors "to the manner born" may perchance have received some more vivid idea of the life of their remotest ancestors. We still need much more light than we now have. Some day a lacustrine dwelling may be discovered in a Northumbrian "lough." As prehistoric archæology is rather a fashionable pursuit, is it too much to hope that greater attention may be rendered in future to the careful observation and preservation of these primæval antiquities such as I have described? There is scope, as there is need, still for diligent workers in this country, whom we would gladly welcome to our aid. Cannot much more be done to prevent the destruction of ancient monuments, which once demolished can never be restored?

A WORD OF CAUTION.

But I would interject just a word of caution. We all remember how Sir Walter Scott's antiquary, Monkbarns, found a Roman prætorium, and held to the belief till Edie Ochiltree assured him "he minded the biggin o't." An antiquary in Northumberland was once showing a friend a "Druid" circle of stones, which proved to have been placed in that position by a farmer for breaking in his horses. A standing stone may turn out to be a rubbing post for cattle. Outbursts of basalt rock have been mistaken for British barrows, and diggings for coal or iron of mediæval or recent times for ancient pit dwellings. In jest, zealous scientific friends may have formed in rock face or boulder incised cups, which were certainly not prehistoric, in order to deceive an archæologist passing by. Then as to the vast antiquity of those interred by inhumation or cremation in undoubted ancient British or prehistoric burial-mounds. I would like to call attention to the fact that at Warkshaugh a family barrow with stone-lined graves and cinerary urns, and also a single well-made cist in the station garden at Chollerford, both occupy sites which, but for embankments, would still often be under the level of the waters of the river North Tyne at flood. Nothing but a chert thumb-flint and an axe-hammer made of a split nodule, with a cinerary urn and food vessel, was discovered in the former, and only a small flint knife in the latter. Do they date from Neolithic times, as at first glance would appear? Or are they very much later indeed, seeing that the river bed and its level in flood time has changed so little in all these ages? Of this, however, I think we may feel sure, that there has been a continuity of life from these far-off days of the stone-using Iberic tribes, our remotest ancestors in Northumbria, through Gadhelic and Cymric stocks—as well as by Roman, Saxon, and Norman—until now. We cannot tell how much is our national indebtedness even to prehistoric progenitors—their various characteristic qualities enriching our modern life, and quickening it to future and greater ends, under the guiding control of natural laws, which are the expressions of will and power that are Almighty and Divine. "That which they have done is but earnest of the things that they shall do." For

I doubt not thro' the ages one increasing purpose runs,
And the thoughts of men are widen'd with the process of the suns.

STAG'S HORN IMPLEMENTS FOUND WITH WHALES' SKELETONS.

Professor Sir W. Turner, F.R.S., read a paper on "Implements of Stag's Horn associated with Whales' Skeletons found in the Carse Lands of Stirling." He said: Those who are acquainted with the valley of the Forth know that the river Forth winds for many miles through an extensive plain called the Carse of Stirling. This plain is a raised sea beach, which reaches from 5 or 10 to 30 feet above the present level of high water. Geologists regard this beach as a post-glacial accumulation of marine origin, for the shells which it contains are not Arctic, but those of molluscs now extant in the seas of Scotland. In the subsoil of this raised beach the skeletons of large whales have from time to time been found, and as many as seven well authenticated specimens have been recorded. They were all got under almost similar conditions, imbedded in a blue silt which underlay a former peat moss, at a depth of usually three to five feet below the present surface of the ground, and at levels varying, it is said, from 5ft. to 25ft. above the present high water mark. At the time when these whales were stranded the estuary of the Forth would have extended some eight or ten miles to the west of the site of the town of Stirling, and there must have been a sufficient depth of sea to permit with a flowing tide large whales to swim many miles further west than is now possible, with the risk, however, of becoming stranded as the tide receded. It has been customary to speak of these whales as Greenland whales, by which term I presume has been meant the right whale, *Balæna mysticstus*, which is an Arctic species. But the skeletons which I have examined did not belong to the genus balæna, but to the genus balænoptera or the finner whales, several species of which now frequent the British seas. I have identified one skeleton as that of *Balænoptera musculus*. Associated with certain of these skeletons, implements of stag's horn have been occasionally found. The first specimen on record was obtained in 1819 on the estate of Airthrey, close to the east gate of approach to Airthrey Castle. Mr. Robert Bald, who described the finding of this skeleton, stated that close by it two pieces of stag's horn were also found, through one of which a hole of about an inch in diameter appears to have been bored. In 1824 the skeleton of a large whale was exposed in digging a ditch on the estate of Blair-Drummond. Along with the skeleton was found a fragment of a stag's horn, said to be similar to that got along with the Airthrey whale, and with a similar round hole bored through it. Mr. D. Milne Home, in his work on "The Estuary of the Forth," states that Mr. Home-Drummond had informed him that a small piece of wood was found in the hole in the horn which fitted it when found, though it has since considerably shrunk.

Unfortunately, no trace of any of these pieces of stag's horn can now be found. It can scarcely be questioned that the two horns with holes in them had been fashioned into implements by human hands, but neither Mr. Bald nor Mr. Home Drummond describes the shape of the pieces of horn, nor states the probable use to which they had been applied. Several writers who have subsequently referred to these specimens have, however, described them as lances or harpoons; but the brief statements about them by their discoverers scarcely justify this inference, for in the fitting of a handle into either of such weapons a hole would not be bored through the weapon, but into one end of it. It is with peculiar satisfaction, therefore, that I have had an opportnnity of examining a third specimen of a stag's horn made into an implement and associated with a whale's skeleton. In 1877, the skull and other bones of a balænot era were exposed in the course of drainage operations on the estate of Meiklewood, a few miles west of Stirling. Resting upon the front of the skull and lying vertically in the blue silt, was an implement made of the horn of a red-deer which possessed the following characters:—It was 11 inches long and 6½ inches in its greatest girth. It consisted of a portion of the beam of the antler immediately above the frontal burr and brow antler, and included that part of the beam from which the tine second in order from the frontal burr had sprung. This tine had been broken off, and a hole had been bored at that spot completely through the thickness of the beam, the centre of which was 4 inches from one end and 7 inches from the other. The greatest circumference of the implement was at the part through which the hole was bored, and here it was slightly curved. The aperture where it opened on the convexity from which the tine had sprung was oval and elongated in the long axis of the beam, its dimensions being 1¼ inch by ¾ inch; on the opposte aspect the aperture was almost circular and ¾ inch in diameter. The shorter segment of the antler was truncated and shaped so that it could have been used as a hammer. The opposite end was bevelled and smooth, and polished to a sharpish edge, like that of an axe or chisel. In the process of forming this edge one side of the antler had been rubbed down much more than the other, so that the edge was formed by the hard solid part of the antler. The smooth shining surface of this edge contrasted with the rough, tuberculated appearance of the rest of the antler. A piece of wood 1¾ inch long occupied the hole in the antler. Though much shrunk, so as not to fill it, it was obviously the remains of a handle with which the implement had been provided. The circular shape of the hole on one aspect, and its oval form on the other, leads one to infer that the handle had been a circular stick secured in the hole by wedges of wood, after the manner in which the handle of an axe is now fitted. From the hole not being midway between the two ends the implement was not evenly balanced and the bevelled end was longer than the hammer-shaped extremity. The selection of the end of the antler furthest from the frontal burr for the formation of the bevelled edge enabled the maker to obtain a denser part of the horn for the cutting edge. When used with a handle the bevelled end could be employed as an axe, and without the handle it could be used as a chisel. I have little doubt that the implements found along with the Airthrey and Blair Drummond whales corresponded in shape to that which I have just described. Implements made of the antlers of the red deer are well known to archæologists, and drawings and descriptions of several varieties may be found in various publications. As a rule they seem to have been fashioned into hammers of sharp pointed implements. The particular pattern found with these ancient whales is somewhat unusual. In the Royal Museum at Brussels, however, are some specimens from the Belgian bone caves which closely resemble in shape that which I have described. I may refer especially to those found in the Caverne de Montaigle, which were perforated with a hole for a handle, had one end truncated and the other bevelled to a chisel-like edge. The discovery of these horn implements proves that when the fertile land now forming the Carse of Stirling was submerged below the sea level, the surrounding high lands were inhabited by a hardy Caledonian race, who manufactered from the antlers of the red deer useful tools and weapons. I have already stated that there is nothing in the form of these implements to lead one to suppose that they could be used in the chase of the whale as lances or harpoons. It is probable that the whales, by the side of which they were found, had been stranded during the ebb of the tide, and that the people had descended from the adjacent heights, and with the aid of their chisels of horn had spoiled the carcase of its load of flesh and blubber. In support of this view I may state that the three skeletons along with which the implements were found were lying in proximity to the edge of the Carse land, where it approached the adjacent high ground. It is expressly stated by Mr. Blackadder that the Blair Drummond whale was found within 400 yards of the margin of the Carse clay. The Airthrey whale was exposed near the high ground of the Abbot's Craig; whilst the Meiklewood whale was lying at no great distance from the foot of the Gargunock Hills. We cannot fix a precise date when the men whose implements we have been considering lived in Scotland. It was of course long before the Roman occupation of Britain, and preceded the beginning of the present adjustment of land and sea on our coasts. It is doubtless to be referred to the period termed the Neolithic, the termination of which, according to the estimates of M. Morlot and other geologists, could not have been less than from 5,000 to 7,000 years ago.

Dr. HODGKIN expressed great interest in the reading of both papers. All Northumbrians, he said, knew Mr. Hall's work. Some of their friends, however, might not know how diligently he had been working out these prehistoric finds. In his little country parish, it was an extremely interesting sight to see a country clergyman doing his spiritual work heartily and well, and, at the same time, able to carry out those interesting investigations into the exceedingly remote past which the excavations revealed to them. Mr. Rowe Hall alluded to one excavation which he (the speaker) had the privilege of being present at. He would not forget the time. It was on Pitland Hills, overlooking the North Tyne. There they saw the cairn in which they might suppose, ages ago, the chief was laid among the wails of his people. The Bishop of Newcastle was with them, and, stripping off his coat, he "howked," as they termed it in Northumberland, for two or three hours into this cairn. He (the speaker) asked him if he was not afraid of being brought up on a warrant by the Secretary of State for opening a tomb without a warrant. His lordship replied he would take his chance. He remembered the food vessel and cinerary urn, which had to be hardened by fire in order to prevent it giving way and then they saw the crouched up skeleton of the poor chief. His chest was greviously broken in, but the skull was fairly perfect. It was also interesting to observe how the hut circles of Northumberland resembled those of Dartmoor. (Applause.)

Dr. Thomas Wilson, of America; Dr. Embleton, of Newcastle; Dr. Garson, and Mr. Adam Robertson also took part in the discussion which followed this paper.

ORIGIN OF HUMAN FACULTY.

Prof. G. J. ROMANES, F.R.S., read a paper on "The Origin of Human Faculty." He said that he had been requested by the council of the Neurological Society to read a paper on a recently published book of his own, for the purpose of raising a discussion on the psychological doctrines which are therein presented. The aim of the treatise was twofold. First, to meet upon their own ground those various writers—psychological and theological—who maintained that a great exception must be made in the case of the human mind to the otherwise uniform law of continuous evolution; and, secondly, to indicate the probable causes, and thus to trace the porobable history of the transition between the intelligence of the lower animals and the intelligence of man.

The paper was listened to with great interest, and a short discussion followed.

BRAIN FUNCTIONS AND HUMAN CHARACTER.

The following paper on "Some Observations on the Relations between Brain Functions and Human Character" was read by BERNARD HOLLANDER, of Vienna:—The failure of a scientific basis to human character and a correct analysis of the fundamental human dispositions must be attributed to the want of knowledge of the functions of the brain and nervous system, and to the preference with which men have hitherto followed metaphysical speculations on the human mind in preference to physical research. The study of comparative anatomy, of craniology, of the evolution of the intellect, of heredity, of mind in animals, of the growth of intelligence in children, and the perversion of the faculties in the insane, and other studies which help us to understand human nature, are of comparatively recent origin, while the most important of all—that is, brain-physiology—is still most obscure. It is only recently that the plurality of the functions of the brain has been demonstrated scientifically; and though a number of English and foreign investigators have succeeded in localising centres for motion and sensation, we are still in need of a method which will enable us to demonstrate centres of ideation or thought. A number of experiments have been made on the cortex of animals, with the result of defining distinct regions for motion and sensation, either by exciting definite portions of brain, and watching the movements that occur, or by destructive lesions and observation of the loss of movements; and though the results in themselves were not, hitherto, considered to be of direct value to the student of mental science, they demonstrate, as will be shown, the physical parallel of certain emotions, and confirm actual localisations made empirically by earlier investigators, whose work, however, has been long ago rejected on account of the insufficiency of their method. This communication is intended to be a collection of facts relating to the subject of brain-functions, in their subjective and objective aspects, with the view of showing the possibility of a "scientific" phrenology and the necessity of re-examining the empirical observations made by Dr. Francis Joseph Gall, bearing in mind the defects of his system and the overstrained pretensions of his followers. (A.) Experimental physiologists are agreed that the most intense centres for movements of the "facial" muscles are in a portion of brain extending from the gyrus centralis anterior to the latter end of the middle frontal convolution. This localisation is confirmed by pathologists, and all observers are struck by the frequency with which disease of the "facial" nerve occurs, together with loss of articulation of speech. This brain-area corresponds with that in which Gall located his "organ of mimicry," which he supposed to be the physical condition for a talent for the imitation of gestures of other people, and which is noted to be often accompanied by a talent for imitating the voice of others, thus constituting the necessary fundamental dispositions to the art of "acting.' (B.) Professor Ferrier's localisation of the "gustatory centre" at the tip of the lower temporal convolution, the centre which sometimes gives rise to ravenous appetite, or sitophobia, exemplified in certain forms of insanity, is exactly the same as that of "gustativeness" or "alimentiveness" as made by the early phrenologists, and which they supposed to incite us to the sensual enjoyment of the palate, and the activity of which is independent of hunger and thirst. (C.) Professor Ferrier considers intellectual attention to be essentially ideal vision, and says that when we are concentrating our attention the ideal object is held in the field of clear vision by appropriate ocular movements, which react back on the centres of vision and keep the ideal object in the field of clear consciousness, and through this recall its various sensory and motor associations. He comes to the conclusion that the centre of vision is the centre for concentration of attention. Professor Ferrier supposed the angular gyrus to be the centre of vision, but it is now shown by Professor Schäfer and by many foreigh observers to be in the "first occipital convolution," the same area in which George Combe located the same power, naming it "concentrativeness," which he supposed to enable one to fix one's attention for a long time on one object. (D.) The area, a portion of the ascending frontal convolution, in which Professor Ferrier locates the centre for movements of the elevator muscles, the same which are called into action in joyful emotions, and enable us to elevate the cheeks and angles of the mouth as expressed in smiling, is the same in which George Combe located the organ of cheerfulness—badly termed "hope" on account of the grandiose delusions which are created when the organ is in an excited state. Sir James Crichton Browne and others have noted that in the disease known as general paralysis of the insane there is almost invariably optimism, insane joyousness, delusions as to wealth and grandeur, while the earliest physical symptom is trembling at the corners of the mouth and at the corners of the eyes; and Dr. Voisin explains this condition by supposing the existence of a centre of exaltation. (E.) Mr. Herbert Spencer, the eminent philosopher, who wrote in his younger days some clever articles on phrenology, in which he expressed his belief in Gall's system, and showed himself an acute observer, localises in the latter halves of the lower frontal convolutions in the area which was thought by Gall to be connected with "visions," the faculty of "reviviscence." His theory is that the proposed faculty is "the chief agent of imagination, and that it affords a tangible explanation of mental illusions." He quotes many examples of men of powerful imagination like Dante, Tasso, Swedenborg, and others who have been subject to mental illusions, and asks his critics to examine the likenesses of poets to see the predominance of the corresponding skull-area. Modern pathologists thought at one time that spectral appearances were caused by disturbed brain-centres of vision; but an examination of the cortex of the insane has shown that the supposed visual brain-area is hardly ever affected, while the posterior zone of the frontal convolutions always shows adhesion, decortication, and wasting. Further evidence is deducible from the fact that the facial expression of visionaries can be produced by physical excitation of the area in question, out the attempt to analyse the supposed faculty meets with difficulties. All we are entitled to assume is that this area is concerned with the powers of imagination, and that when it is in a state of disease or over-excitement it may give rise to hallucinations and visions. (F.) Lesion of the angular gyrus is shown by Munk and others to cause so-called "physical blindness" (Seelenblindheit), and numerous experiments demonstrate the "non-perception of danger" in those animals in which this gyrus has been destroyed. Adjoining it, *i.e.* at the extremity of the ascending parietal convolution, Professor Ferrier locates the centre for movements of the "platysma myoides muscle," on the importance of which, in the expression of fear, both Darwin and Sir Charles Bell dwell, while Duchene calls it the muscle of fright. The whole area corresponds with the area in which Gall located his organ of "apprehension," afterwards called "cautiousness," which he supposed to be excited when we are in a state of anxiety or fear, and which region he found enormously developed in persons known to take alarm easily and who could be easily terrified. (G.) Darwin's and Herbert Spencer's description of the physical expression of the "irascible" emotion in animals, as, for instance, when about to attack an antagonist, is a drawing back of the ears, gnashing of the teeth, and growling; while Professor Ferrier observed that the excitation of the superior temporosphenoidal convolution in monkeys and the corresponding convolution in dogs caused retraction of the ear, accompanied occasionally by a sudden spring or bound forward; and in cats it caused opening of the mouth, associated with vocalisation and other signs of emotional expression, such as spitting and lashing of the tail as if in rage. This area is no other than that which Gall found so prominently developed in all carnivorous animals and in murderers, and which he supposed to be the physical condition of the destructive propensity or irascible emotion. The examination has not been completed, for, even limited as it is, it will excite much criticism. Little has been said of the analysis of human character, and no mention has been made of the arguments in favour of the plurality of functions of the brain, as, for instance, the necessity of their being special ideational centres ; otherwise it would be impossible to explain the hereditary transmission of peculiarities of character and mental characteristics from parent to child, for the subject is a wide one and cannot possibly be treated in one communication. Only one humble wish the author desires to express before concluding his paper, and that is : May his critics give the subject a fair consideration, and disregard the prejudices of ignorance and superstition.

ILLUSTRATING ANATOMY OF THE BRAIN.

Professor Fraser next read a paper "On a New Method of Illustrating the Topography of the Brain to the External Surface of the Head." The author treated first of the manner by which he prepared his heads, so that they should be in a perfect condition through and through ; then of the large photographic apparatus which he used for reproducing serial dissections of the head and neck life size ; also of the manner in which, by combining several views direct from nature on one plate, he had been able to make the head practically transparent. He explained also how by a system of tapes placed in a fixed manner on the head, he had shown the diminution of its round when projected on a plane surface, and that one could read off the relations of every portion of the brain, internal as well as external, to the skin measurements at a glance. He then referred to the many useful applications of the method both for anthropological and many other practical purposes.

"NOTES ON CLASSIFICATION IN SOCIOLOGY."

Mr. George Weddell contributed "Notes on Classification in Sociology." He said the study of social science has been retarded by misconception as to its nature. It is popularly supposed to consist of a grouping of philanthropic or social movements, such as co-operation, sanitation, technical education, and the better housing of the working classes. By a number of more thoughtful people it is confounded with political economy, which ought to be considered only as one of its important branches. Sociology might be distinguished from the allied sciences as the study of man in union with his fellows—considering the individual as the unit of society or social cell. If we divide the individual we touch upon biology (or physiology) ; if we examine merely varieties of individual type we enter on anthropology. In studying combinations of individuals we reach sociology. The scientific conception of society must include and co-ordinate all known social phenomena, not merely those of one class. The Jewish or Christian conception of society was of a kingdom of God—a religious unity ; the old Roman view was that of an empire—a political unity ; the modern British idea is of a universal market—an industrial unity. Each of these conceptions evinces a tendency or leading characteristic of peoples in various ages and stages ; but each is insufficient as a general view of society. The conception of the two great masters of sociology, Comte and Spencer, is that society is an organism, built up of individuals, and sustaining its existence by means of organs, comparable in many respects to those by which animal life is carried on. This treatment of the science as organic gives it a unity which was impossible when it was studied through the dry bones of statistics. It supplies the missing link which unites the industrial with the political, and the political with the other organs, while it more clearly distinguishes the functions which each performs in the social body.

FIRE MAKING IN NORTH BORNEO.

A paper by B. J. Skertchley on "Fire making in North Borneo" was read by Mr. J. G. Bloxam (secretary.) The author explained the processes in use among the natives in obtaining fire.

ON SOME BORNEO TRAPS.

A second paper by Mr. S. B. J. Skertchley, "On some Borneo Traps," was read by Dr. Howdon (secretary.) The author gave interesting descriptions of native traps for the capture of animals and birds.

MANNERS, CUSTOMS, RELIGIONS, & SUPERSTITIONS OF SOUTH AFRICAN TRIBES.

Mr. James Macdonald read the following paper on this subject :—In my first paper I followed, in great measure, the order suggested by the series of questions drawn up by Mr. J. G. Frazer, of Trinity College, Cambridge. Following that order

Murder would be the next subject, but though I have lived for twelve years among South African natives, first among the Giacas, and subsequently among Hlubies, Pondos, Gialekas, and Pondomise, no case of murder ever came under my own observation, except such as were dealt with under English law. In a general way I am familiar with native customs regarding this crime, such as expulsion from tribal territory, confiscation of goods, and other forms of punishment, but I prefer to delay consideration of the question till I have obtained the opinions of others who may be more familiar with the subject.

PROPERTY AND INHERITANCE.

The chief holds the land for communal purposes, and each member of the tribe cultivates as much as he requires. During the time a man occupies and uses land it is regarded as his own, and no one, not even the chief, can dispossess him without ample compensation. At his death his ground passes to his heir, but he can neither will nor otherwise dispose of it to any other. Even should he during his lifetime give a portion to another this is regarded as simply a loan, and does not in any sense interfere with the heir's rights. Should the borrower clear and improve the land at great cost and labour, no compensation can be claimed from the heir. A man's land cannot be put under arrest or taken possession of for debt or any form of liability while he remains a member of the tribe. For certain crimes—murder, arson, theft, &c.—he can be expelled the community, and if taken in the act may be slain with impunity. He is a wolf. A considerable portion of arable land is always reserved with the view of giving out new plots either to younger sons or to men who may from time to time join the tribe. The grazing lands are the common property of the tribes, and a man can pasture his flocks and herds wherever his fancy may lead him, only that the vicinity of the "Great Place," *i.e.*, the chief's dwelling, is reserved specially for his own use. In the matter of inheritance, though apparently confusing, their system of law is better defined than in almost any other branch of jurisprudence. When a man has but one wife his eldest son is his heir and inherits all his civil and material rights as a tribesman. He is also entitled to a certain proportion of all movable property. The residue may be divided between other members of the family in any proportions. Daughters can thus inherit, though in practice this seldom happens. They are supposed to get married and add to the father's wealth, and when past the ordinary age of marriage are regarded as a failure, and become little better than domestic drudges, or so much useless lumber. Theirs is a rather hard lot. Where there are more wives than one the position is complicated by a variety of regulations. The first wife may not be and seldom is the chief wife. It is the latter's eldest son who is the heir, but at the same time the first wife's eldest son has a claim superior to that of other sons of subordinate wives. During the father's lifetime he usually apportions his property to the respective households, always subject to the heir's claims, and any property not so apportioned is equally divided, the heir taking the larger share according to a recognised ratio. When a man has no heir he can will his movable property to others than relatives, subject to a certain claim his brother, if his mother's son, has. His civil rights lapse and revert to the chief in whose gift they are, to confer on whom he will. When a man dies both heirless and intestate, his brother, if his mother's son, is the heir-at-law, or, failing such brother, then the nephew. If he had no full brother, then that one of his father's sons highest in rank by other wives is the heir, and takes all the rights which would belong to a full brother. The wife's relations do not inherit, nor do the daughters or sisters of the deceased in an intestate estate, nor under any circumstances other than the very rare cases already referred to. It not unfrequently happens that the youngest son is the heir, as the chief wife may be the one married last, and as her son is the heir, should she have only one, he, though the youngest of the family, takes procedure of all his brothers, and is trained and educated in all tribal customs and traditions to take his father's places. Offices of honour and power often pass from father to son, as also such arts as medicine, sorcery, and other occult sciences.

FOOD.

Almost all articles of food are used, though certain animals are unclean to men but not to women and children, while others are unclean to all. To men, swine, hares, fish, domestic fowls, ducks, geese, and turkeys are unclean, but all wild fowl may be eaten. Women, again, may eat all the above, except fish, which is classed with serpents, and must not be partaken of by any. Men frequently hunt hares and wild pigs for the use of their women and children, but though they may kill and dress them, they must not be eaten on pain of being polluted. There is no reason assigned for abstinence from the articles named, nor do they explain why they should be unclean. The observance is simply referred to custom, and that none of their people ever did otherwise. There are no specified times when particular articles of food may be eaten or abstained from, on the ground of such articles being unclean, though, for other reasons, there are restrictions imposed, but these will fall to be considered in other connexions. At ordinary meals men eat apart, and are waited upon by the women and children, who, as a rule, eat after the men finished theirs, though it is a frequent habit for men to throw small portions to the children, who generally sit in a group together waiting their turn at the food basin. The only reason that can be assigned for men and women eating apart is the subordinate position of woman, who practically becomes a chattel after marriage, and whose duty it is to attend upon her husband and his friends, receiving such signs of favour as may be extended to her with due thankfulness. To act otherwise involves the taking of another wife, who, for the time being, becomes favourite. What has been said of eating applies to ordinary everyday family life, but to this habit there is in times of great plenty an important exception. Then the principal meal of the day is taken about 11 a.m., and in public. A little before that time each man in the village sends what has been prepared for him, ordinarily boiled millet and fermented milk, to some shady or sheltered spot, and all slowly saunter to the appointed place, where they sit and talk, taking their meal very leisurely, and frequently exchanging portions, when different articles have been prepared for them. The women on such occasions usually eat in their respective huts with their children, and any man or woman who, through accident, or as a stranger, has no food, shares in whatever is going. They are, however, supposed to be fed by the head of the village; it is he alone who is responsible for hospitality, Often the same basin or tub is used to hold the food of a considerable number of persons, and in that case each has a large spoon with which he lifts a portion, eating it with the aid of his fingers. Giving a stranger a separate vessel apart from the family basin would be regarded as an insult. It is supposed to indicate a fear of some contagious disease, such as leprosy. In the evening the meal is taken in the hut, but otherwise differs in no essential from the forenoon meal, except that flesh is more frequently used at night than during the day which, however, may be regarded as equivalent to late dining! There is no cannibalism among South African tribes, though in former ages the Basutos did undoubtedly eat human flesh, but in what connections tradition does not make clear; most probably enemies slain in war. Prisoners seem to have been retained as domestic drudges. They neither use the blood of men or animals for any purpose of ordinary food, but both enter into the composition of certain of the magician's decoctions, There is no objection to blood being seen or handled at any time, only men must neither see nor touch the blood of menstruation.

FASTING.

Fasting is a recognised semi-religious practice, and is observed after the death of a chief or relative, and on special occasions when great events are expected to happen. When a chief dies the whole tribe fasts, usually for one day, but in special circumstances longer. At the conclusion of the fast, the ordinary method of life is resumed without any ceremony. The seclusion of widows after the husband's death is called fasting, though this does not imply abstinence from food. Among the tribes whose customs are under consideration, fasting has in great measure been discontinued, but according to their own traditions fasts were observed much more frequently in former times and for a much larger number of objects, but chiefly connected with disease and death, together with exceptional events; the appearance of a brilliant comet, an eclipse of the sun, and magicians' predictions.

AN EXTRAORDINARY DELUSION.

About 1857, certain of the South African tribes became possessed by an extrordinary delusion—and I refer to it partly to illustrate the nature of their fasts and partly also to show the power possessed by the magicians. Shortly before the date referred to there had been a good deal of guerilla warfare between the English settlers and the native tribes, resulting in confiscation of territory. Under this the natives smarted, and cast about for a means of revenge. In previous wars they had been heavily handicapped by the necessity of guarding their cattle in comparatively open country, when cavalry could operate with effect. An imposter named Umlaujeni predicted that if the confederate tribes slaughtered all their cattle, destroyed every peck of corn, and left the ground untilled in the spring, that at a given time their ancestors would rise and drive the English into the sea, whence they came. He farther alleged that he saw in his visions the cattle belonging to the ancestors coming in huge droves over the hills, and that, after the expulsion of the English, every man could have as many as he had provided folds for before the eventful day. The corn pits also were to be filled without tillage. This delusion took possession of the fevered imagination, and a number of tribes destroyed every hoof, and left their corn lying in heaps to rot. Feasting, dancing, and warlike demonstrations occupied their whole time. In vain the Government tried to avert the impending ruin, but nothing could be done but await the development of events and prepare for war. Before the arrival of the eventful day, which happened to be the full moon, solemn fasts were appointed and observed. Every hill smoked with sacrifices offered to the ancestors. And on the evening preceding the resurrection day a solemn service was held under a hill near the mouth of the great Kei river, at which tens of thousands of expectant men were present. The sign given by Umlaujeni was that on the morning succeeding the full moon, the sun was to rise double. During the memorable night not an eye closed. Young men feasted and drank, danced and carried on high revelry, while the older sat in groups in silence or walked anxiously about the huge fold prepared for the cattle of the chiefs. As the night wore on and all things remained silent and still, under the bright moon and feebly shining stars, the anxiety deepened till the dawn of day proclaimed the sun's return once more. As the king of day showed the edge of his disc above the horizon all eyes were turned to the east; slowly and majestically he rose above the horizon, but his companion lagged behind, and already black fear entered hearts which a little ago beat high with hope and expectation. Umlaujeni declared that they had mistaken the day of the full moon, and predicted triumph on the morrow. The next twenty-four hours was but a sad time. Such food as had not been destroyed was quite exhausted, and as afternoon wore to evening hunger reminded men of their possible plight should Umlaujeni be again wrong. But not a murmur was heard till once more the sun appeared in solitary majesty. After that it was in vain that skilled and daring warriors urged their men to follow them in a bold rush upon the colony if but to secure food for a perishing nation. Along the frontier every pass was securely guarded, nor were hungry and dispirited men likely to force them. What followed is ordinary history, with which in these papers we have nothing to do, nor with this delusion except as illustrating the magician's power and the occasions on which solemn fasts are observed.

SUPERSTITIONS AS TO FOOD.

Occasionally the flesh of the lion or spotted leopard is cooked and eaten by men—chiefly warriors—to make them courageous, but the practice is not general, though found among all the tribes. Portions of such animals are used by magicians (war doctors) as ingredients in preparing the decoctions used for sprinkling the warriors before entering on a campaign, and greater reliance is placed on this than on eating the flesh. There is no objection to eating the flesh and heart of a deer, timidity is not induced by any article of food, but ill-luck and dire calamity would result from a neglect of the doctoring process before going to war.

STORMS.

During the season of growth hail showers are not uncommon, and when the appearance of the sky indicates the approach of a storm the magicians, accompanied by all they can muster, especially women, repair to eminences near the dwellings. There they shout and yell in the most frantic manner to divert the storm from its course. As such storms frequently diverge from the straight line, and occasionally part into two or more sections in their course, all this is attributed to the power of the magicians. He who has the highest skill diverts the storm from his own locality, and should he fail it is because one more powerful than he was working against him and sent the storm on the course it took. Most amusing incidents could be related in connexion with this practice. One must suffice. The summer of 1885-6 was one during which hailstorms were very prevalent. One day a very severe one passed near the writer's dwelling. All the magicians were out and succeeded in diverting it to the next valley. On the following day an old magician came to me expecting to be complimented, and began, "The white chief is indebted to us to-day. There would be no fruit in his garden if we had not gone out to meet the storm." I asked where the storm had gone. He mentioned the valley where his own paramount chief resided. I then said, "You are a curious doctor; you save my garden and send the hail to your own chief. What will he say if I tell him this morning's conversation?" A roar of laughter burst from the bystanders, and my friend, hiding his head in his blanket, fled precipitately, leaving the white man for once master of the situation. There are no rules observed in reaping, threshing, winnowing, or grinding. Nor are any special observances or uses in connexion with the implements used in agriculture. In connexion with agriculture, rain-making might be appropriately considered, but as rain doctors, lightning men, *et hoc genus omne* must have a chapter devoted to themselves, it is better to defer these subjects till they can be grouped conveniently together.

WAR.

Enemies slain in battle are not as a rule mutilated, though this may happen. Certain tribes deem it necessary to rip up the abdomen of the fallen. If this is not done they may suffer when decomposition sets in and the body becomes distended with gas, the magicians belonging to the tribe of the slain being able to work witchery and bring defeat by means of this gas confined in the bodies of the dead. The war doctor may order any noted warrior slain to be decapitated. After this the head is boiled, and the roof of the cleaned skull made into a bowl for holding the charming medicine with which he sprinkles the soldiers. War medicine from such a vessel is supposed to have special virtue, and to convey to others something of the spirit and prowess of the original owner of the novel cup. When the army returns, whether as victors or vanquished, there are no ceremonies observed beyond the bestowal of honours for bravery; nor are any ceremonies prescribed to the man who has slain an enemy. The act brings him honour and adds to his reputation, but it does not necessarily imply reward or promotion. The following, from the conversation of a Giaca named Go, a most intelligent man, who was attached to the staff of the Hon. Charles Brownlee, who records the incidents, will serve to illustrate some of their war practices. Brownlee says: "Go sitting by the camp fire would begin, 'In the last war I was in the colony; two other men accompanied me. We went to Alice, but the Fingoes were on the alert, and had their cattle carefully guarded, and we could get nothing—*i.e.*, by theft. I crept up near their camp fire, where one of their diviners was performing an incantation and cursing against the the Giacas. He had the dried fingers of a dead man in his hand, and was shouting and dancing about in the most frantic manner, predicting victory and success to the Fingoes, and pronouncing maledictions against Sandili, saying, 'Little jackal of the Giacas, get out of this,' the people leaping and shouting 'We assent.' On the following day I met the Giaca army, under Oba, on the way to attack the Fingoes. Two ospreys had in the morning flown over the Giaca army, uttering piercing shrieks. This the old men considered a bad omen, and begged Oba to return and have the army re-charmed, as the flight of the birds boded defeat, and indicated that they were thus to feast on the eyes of the slain. But Oba was young and obstinate, and would not be terrified by the shrieks of birds. This was the first time he was in command, and would listen to no one, nor would he be terrified by Fingoes or birds. But the army was disheartened, and many feared that by disregarding the omen they were going to certain destruction. . . . The order was given, and Quaraua, a brave warrior, led the van. From the crest of the hill we saw the cattle with six men guarding them, and they advanced towards us shouting "Basoliever," *i.e.*, "Evil has been said of them," referring to the previous night's incantations. When quite near they fired a volley, shooting Quaraua through the body. He was led back, his horse covered with blood. This was enough. The warriors shouted, "We have been warned by the ospreys, Our leader is killed,' and with this the army turned and fled, though up till now only six Fingoes were in sight opposed to us. Oba did all in his power to stay the panic. He prayed and begged the Giacas to act like men. He called them cowards and women; he broke the heads of his flying men. He might as well have tried to stop a stream after a thunderstorm. He declared he would die rather than be a sharer in such disgrace, and was at last carried forcibly off the field by his attendants.' Oba, headstrong as he was brave, led a somewhat chequered life, but to the end of his days he remained a fine specimen of the Giaca of a past generation. I knew him in his old age when he occupied a paltry Government location, and often thought how bitter his feelings must have been when he contrasted his actual position with his prospects in early life as heir to one of the most powerful chieftainships in South Africa. But the object of these papers is not to record historical events, so we must say farewell to both Go and his chief Oba."

REPORTS.

Reports of the Occupations Committee and of the North-Western Tribes of Canada Committee were also submitted.

CONFERENCE OF DELEGATES.

A conference of delegates of corresponding societies was held in the afternoon, in the New Assembly Rooms, under the presidency of Mr. W. Topley.

THE TEMPERATURE OF RIVERS.

Dr. H. R. Mill, of the Royal Scottish Geographical Society, drew attention to the report of the Committee on the Surface Temperature of Rivers and Estuaries, and said he should be glad if the delegates present representing societies which had not yet seen their way to take up the work of making observations on the water in their own neighbourhood would endeavour to find out some of their members who would be able and willing to make such observations. If they would communicate with him, instructions would be immediately sent out for setting the observations a-going.

Mr. J. Brown, of the Belfast Natural History Society, thought the work might be taken up by the rainfall observers.

Mr. A. S. Reid, M.A., said the East Kent Natural History Society had taken up the work.

Dr. Mill said the work did not clash with that of any other society carrying on meteorological observations.

WATER SUPPLY, &c.

Mr. De Rance, secretary of the Underground Water Committee, said that committee was appointed fifteen years ago, in Belfast, to inquire into the water of new red sandstone and permian formations as a source of water supply to towns. A series of questions had been drawn up which practically grasped the whole subject, and they would be supplied to those provincial secretaries who might desire to have them.

ERRATIC BLOCKS AND BOULDERS.

The committee to inquire into erratic blocks had made a report on the more important boulders, and the position of various boulders had been recorded.—The Coast Erosion Committee had also published a report, and a very large amount of valuable information had been put together by Mr. Topley.

Mr. W. Gray (Belfast) having undertaken to catalogue the result of observations in the counties of Antrim, Down, and Derry,

Mr. De Rance said it was important that the boulders of Ireland should be recorded in the same manner as they were in England, and suggested that a committee might be formed in Ireland, which could eventually be amalgamated with the present English committee.

GEOLOGICAL PHOTOGRAPHS.

Prof. Lebour said that, with regard to geological photographs, there was the greatest possible unanimity in Section C. The matter had been taken up by Prof. Geikie, and the Committee of Recommendations had advised a grant of £10, whereas only £5 was applied for, thus showing the cordial manner in which the committee had met the request.

FLORA OF FRESH WATER RIVERS.

Rev. E. P. Knubley, M.A., said he had been asked to bring before the conference two committees—one for noting the disappearance of native plants, and the other for investigating the invertebrate fauna and cryptogamic flora of the fresh water rivers of the British Isles. The object of the last-named committee was to make systematic investigations of rivers and lakes, and it was hoped that the miscropists would undertake definite scientific work, and be exhorted to take in the physical features of the stream or the lake which they studied, including the geological features, and should take note of the temperature at different periods of the year; and, in the case of the lakes, at various depths.

LISBON GEOGRAPHICAL SOCIETY.

Mr. B. Reis reported on the work of the Lisbon Geographical Society, and expressed a hope that a plan of operations might be commenced in which they could work with English societies.

MINING INSTITUTES.

Professor Lebour said the Committee on Explosives was now in full working order. They had taken up the work of examining the properties of so-called flameless explosives, the main object of which was a philanthropic one. They wished to avoid the possibility of a flame being projected from a blown-out shot in an atmosphere laden with flying particles of dust. If coal dust was there, it would carry an explosion further than it would otherwise go, and change what might be a comparatively harmless accident into a catastrophe of a very destructive character. There was another committee, consisting of the Mining Institutes of the North of England, of the Midlands, and of South Wales, which had joined together for the purpose of carrying out a series of experiments with fans. The reports of that joint committee were of very great value to engineers not only connected with mines, but other works requiring artificial ventiation. The North of England Institute and the others he had mentioned would be exceedingly glad to receive any hints or information which would tend to the better securing of the objects he had mentioned.

Mr. Howard (Chesterfield) said the matter was worthy the consideration of other societies, to see whether or not they could combine in a similar manner.

MISCELLANEOUS.

Dr. Garson made a statement on the work of the Anthropological Section.

Prof. Lebour proposed a resolution to the effect that the relations of delegates to the sectional committees as at present constituted were unsatisfactory, and should be reconsidered by the corresponding societies' committee.

Rev. E. P. Knubley, M.A., seconded the motion, which was carried, and the proceedings closed.

CONVERSAZIONE AT THE MUSEUM.

There was a brilliant scene at night at the Natural History Museum, Newcastle, whither the members and associates of the British Association. and others, were invited to a conversazione by the Local Committee. It was brilliant outside as well as inside. There was the lustrous light that shone upon the corner of the building, radiating into space, making bright lights and dark shadows in the grounds beneath, and beaming down upon the faces of the people who crowded upon the footwalk at the other side of the road. There was an awning stretched over the pavement in front of the Museum, and the two entrance gates were connected with the terrace by covered arches, besides being boarded and carpeted beneath the feet. From the edge of the outside awning, and from the roofs of the covered passages, tiny incandescent lamps depended, making plain the way to the guests. From half-past seven o'clock until the close of the entertainment, there was an almost constant stream of carriages, either arriving or departing, bringing or taking away gaily-dressed ladies and more sombre-looking gentlemen. The crush room, where there were receptacles for cloaks, overcoats, and the like, and where the guests lingered awhile to recognise each other, was a large covered space just at the foot of the Museum Terrace. At the top of the steps, just at the going-in, there were the local secretaries, Professor Merivale and Professor Bedson, with the Sheriff of Newcastle (Mr. W. Sutton), Dr. Philipson, Dr. Embleton, and other members of the local committee, ready to welcome the visitors as they entered. Inasmuch as these were coming in and going out during the whole of the evening, it was somewhat difficult to discover really how many there were present.

The Natural History Museum is just the place for a gathering such as that which it contained last night. There are rooms in plenty, and plenty of room in each. And every room is full of objects interesting to the people in whose honour the conversazione was arranged. There are the huge mammals—the bears, and wolves, and walrus; the Tasmanian devil, the wild cats, the man-monkeys, and numberless other beasts. Then there is Mr. Hancock's magnificent collection of birds. To say nothing of great eagles, and falcons, and owls, and condors, and giant birds from distant lands, there are numberless representatives from the songsters that flit about our woods and fields, besides nests and eggs of every possible variety. Then there is much that is interesting in the insect cases, where bees, and wasps, and ants, and beetles, and earwigs, and cockroaches, and thrips, and dragon flies, and water moths, and butterflies, and bugs, and lantern flies, and grass-hoppers, and sand flies, and fleas—and, indeed. all the insects that fly in the air or crawl upon the earth, are displayed, with pins stuck through their stomachs, their wings and bodies marked with all the colours of the rainbow. Besides these, there are frogs and toads, and salamanders, serpents and snakes, lizards and crocodiles, alligators, tortoises, and turtles. There are countless treasures stolen from the kingdom of the sea—beautiful crabs, and the loveliest of seashells. There are fishes of all kinds—fishes common and fishes rare, handsome fishes and ugly fishes, fishes taken from the river, and fishes taken from the sea. And there is also the wonderful collection of fossils extending from the most recent period to the oldest formation. There is, too, the human skeleton, which might have been used by the anthropologists and evolutionists to demonstrate that man's spinal column has a caudal termination, like that of the other animal to which he is, as they say, allied ; or it might have elicited the remark that is said to have been made by a certain philosopher while gazing reflectively at the skeleton of an ass, "verily, we are fearfully and wonderfully made."

But, after all, those who were there last night, taken as a whole, did not seem to care much about all these things. There was the sweet music of Mr. J. H. Amers's band to listen to, and there was talking to be done—too much talking to permit of an inspection of the museum's contents. That is the business of a conversazione, and the object was in this instance fulfilled, for the guests seemed to be enjoying the whole thing immensely. It was a wonderful throng. It was just such a crowd as Dr. Wm. Anderson might have taken to illustrate his address on molecular motion, delivered on Thursday last to the members of the Mechanical Science Section. It would hardly do to apply the term "molecule" to any unit in the crowd ; but there was a constant coming and going, a never-ending movement, with a decided tendency, however, to rest in the bird room, where, away up in the gallery, the orchestra was playing. But, except for the seats, there was little chance of remaining for a few moments in any one place ; and if anyone looked for a friend he would miss him all at once, and find him reappear from the crowd in some very unexpected and out-of-the-way corner. And there was a brilliancy and a variety of colouring which were fairly bewildering to the eye. The ladies displayed in their attire triumphs of design and the most subtle contrivances of millinery. There is hardly a colour, or a combination of colours, or a contrast of colouring that might not have been found there. All the beautiful tints that Professor Silvanus Thompson showed at the Tyne Theatre on Sunday night by the polarisation of light, all the gorgeous markings on the wings of the *lepidoptera* in the museum, were rivalled here in art. There were silks, and satins, and plushes, and muslins, and numerous other fabrics whose names are intelligible only to the feminine intellect. There were primary colours and all the other colours, in the most lovely and delicate shades. There were charming *coiffures*, glistening with diamonds and gay with flowers. Even some of the gentlemen varied the customary melancholy black, with stars and decorations glittering on their bosoms. With all this warmth of colour—and with sparkling eyes and happy flushed faces to add to the brightness, with the rustling of dresses, and light chatter and merry laughter rippling gently through the throng, the general effect to the eye and ear was peculiarly striking. A gallery runs round the principal room, and upon this many people gathered to gaze down upon the restless congregation beneath, and remained there as if unable to direct their eyes away from the animated scene.

The committee had made ample provision for the entertainment of their guests. Besides the music, there were refreshments ; and, in addition to both the music and the refreshments, there was an excellent exhibition of microscopes and objects by the North of England Microscopical Society, whose president is Mr. N. H. Martin. The objects included many interesting specimens in botany and insect life ; some being of familiar appearance, and others being so marvellously intricate, and having names that were so curiously disproportionate to their own size, that most people could not make out what they were at all. Then there were Gibson's "conches," those wonderfully beautiful drawings of shells which, it is hoped, will find a final resting-place in some local institution. There were also pictures and photographs, lent for the occasion by various people. But the greatest attraction of all was the phonograph, which Messrs. Mawson, Swan, and Morgan were exhibiting to small parties during the evening in the committee room. This uncanny instrument reproduced, in the most natural manner imaginable, everything that was spoken into its ear. It threatened, with the most ferocious emphasis, to consult its solicitor concerning a libel which it alleged somebody had committed concerning its character. Some of the ladies, almost fancying that they were in the presence of the supernatural, declared that they felt quite "creepy"; but one, whose notions were evidently far from superstitious, said that it was "awfully funny"! The whole building, it should be said, was lighted throughout by electric lamps, provided by Messrs. Holmes, the current being derived from the College of Physical Science. Late in the evening a 3,000-candle power Sunbeam lamp—the most powerful light in the world—was illuminated, and the effect of it was fairly dazzling. Later in the evening, too, some of the "lions" appeared, and added to the dignity of the gathering.

The conversazione continued until eleven o'clock, and it was, by universal agreement, as pleasant an entertainment as ever any entertainment was that has gone before it, or as ever any entertainment is likely to be that will come after it.

THE SEVENTH DAY'S PROCEEDINGS.

WEDNESDAY, SEPTEMBER 18, 1889.

MEETINGS OF THE SECTIONS.

SECTION A.—MATHEMATICAL AND PHYSICAL SCIENCE.

The Recorder (Mr. Baynes) intimated that the committee on "The Nomenclature of the Fundamental Units of Mechanics" had nothing new to announce.

STEREOMETRY.

Mr. W. W. H. Gee read a paper by himself and Dr. A. Harden on "Stereometry.' The following is an abstract of it :—This communication relates to the methods used for the determination of the volumes of bodies to which the hydrostatic method is not applicable. The authors have devised a convenient form of the instrument first proposed by Say, and afterwards modified by Leslie, Kopp, Regnault, and Miller. They have also shown that the following method for ascertaining volumes is very generally applicable, and likely to be of considerable service in physico-chemical researches. The body whose volume is desired is enclosed within a vessel of known volume, and then carbon dioxide (or other dry soluble gas) is passed into it for some time. The gas is then displaced by dry air (or other gas), and the volume of the carbon dioxide driven out is ascertained gravimetrically by absorption in bulbs containing caustic potash solution By first filling the vessel with dry air, and then driving it out with carbon dioxide, the volume of the air, and hence that of the body, may also be ascertained volumetrically, but with less accuracy. The gravimetric method is especially applicable for accurately ascertaining the density of soluble gases. For this purpose it is far more convenient than the process of direct weighing as used by Regnault.

SPECIFIC HEAT OF CAOUTCHOUC.

The next paper was on "The Specific Heat of Caoutchouc," contributed by Messrs. W. W. Haldane Gee and Hubert L. Terry, and the following is an abstract : —A number of determinations have been made of the specific heat of Para indiarubber which had been masticated, hydraulically compressed, and then cut into sheets from 0·22 millimetre to 1·40 millimetre thick. The rubber was alternated with sheets of tinfoil and heated for two hours in a steam-jacket at 100 deg. C. A modification of Regnault's method of mixtures was employed to find the specific heat of the hot rubber. Owing to the non-conducting nature of the substance the time of the calorimeter attaining its maximum temperature is as long as ten minutes ; hence it has been necessary to apply special formulæ for the correction due to cooling. Those proposed by Pfaundler, Pape, and Schuster have been used, and the results calculated in accordance with them. The mean of the best-conducted experiments gives for the Para rubber the number ·486. The investigation is being extended to allied bodies, especially the different forms of vulcanised rubber and gutta-percha.

THERMO CURRENTS IN AND RECALESCENCE OF IRON.

Mr. F. T. Trouton delivered an address on the "Temporary Thermo Currents in Iron." The address was supplemented with interesting experiments.

Professor W. F. Barrett read a paper on "The Recalescence of Iron." When iron was heated to white heat, he said, and then allowed to cool in the air, the temperature fell irregularly until it reached nearly obscurity. At that point it suddenly glowed again to bright red heat, and then continued to fall to the temperature of the air. If, on the other hand, a wire were closely watched during the process of heating, it would be found that at the same critical point the wire ceased to become hotter from the application of heat—in fact, a slight chill took place, and the march of temperature was resumed. The critical temperature was associated with numerous other phenomena which were found to take place in iron and steel. In 1869 Mr. Gore discovered that a cooling iron wire momentarily elongated at this temperature. The reverse action or contraction on heating was found by the author in 1873, and also that it was at this temperature iron by the action of heat lost its magnetic properties. Further, a curious sound occurred at this critical temperature, indicating some alteration of structure. Here, too, occurred the curious change in the thermo-electric properties of iron discovered by Professor Tait and associated with this critical point was an interesting discovery made by Mr. Trouton and described in that gentleman's paper. Subsequent investigations both on the Continent and in America showed that at this temperature many other important changes in the physical and the chemical properties of steel occurred, some of which were discovered by Professor Roberts Austen in a recent lecture before the Association. Mr. Tomlinson in London, Mr. Newall at Cambridge, and recently Dr. Hopkinson had given that subject a great deal of attention, and had added much to their knowledge of recalescence and its associated phenomena. The bibliography of the subject and the probable causes of the phenomenon would be contained in the report of a committee which it was proposed to present each year. The committee would consist of Professor Fitzgerald, Mr. Newall, Mr. Trouton, and Professor Barrett.

An interesting discussion followed the paper.

THE CARDIUM.

Mr. John Gamgee read a paper on "The Cardium, illustrating the Nature of Prime Movers and the True Co-Relation of Natural Phenomena." This paper was, owing to lack of time, very much curtailed. The following abstract gives the author's main ideas :—He referred to a new philosophical instrument illustrating that on the inter-action of gases, liquids, and solids, all motion depends, and, without the three, no true prime-mover can be constructed. It is based on the physiological idea that the simple animal cell with its solid envelope, solid and liquid contents, and continual absorption of gases, is a typical engine. It moreover illustrates, and probably for the first time, the true reason for the blood's flow in oxygenation, and Mr. Gamgee quoted Dr. Thomas Young "On the functions of the heart," who stated in 1808 that as far as the functions of animal life depend on the locomotion of the solids or fluids, those functions must be capable of being illustrated by the consideration of the mechanical laws of moving bodies.

In 1878, Mr. Gamgee conceived the idea that all useful motors should be closed cycle engines. In 1880, he made a partially successful attempt, using anhydrous ammonia, expanding it in a compound engine, which developed about nine horse-power, and the exhaust of the engine was at 30 degrees below zero. The fluid discharged was mostly gaseous, and Mr. Gamgee was led to test the validity of the law which assumes that every gas when condensed or compressed, must discharge heat. Experimenting on a large scale with air, he discovered that this heat of compression was entirely due to the mechanical work performed on the confined gas which, by virtue of such confinement, resisted the effort of compression, and hence as the result of such work heat was necessarily evolved. By taking ejectors, guarding them by check valves, erecting them in multiple series on vessels or tubes through which the air might travel on to the main receiver, and operating all these ejectors by means of a high pressure water pump, he perceived that the water by friction would heat, but the air would never rise in temperature. The heat of friction of the water rose often to near boiling point, but under the high pressures the vapours that might rise and mingle with the air heating it were never set free and the air itself remained usually at one or two degrees below the temperature of the circumambient air.

Dalton demonstrated in 1801 that "gases or vapours put together either into limited or unlimited space, each occupy the whole space as if the others were not present." In other words an elastic gas behaves in relation to any other elastic gas as if there were a vacuum. "Therefore," says Mr. Gamgee, "air passing at high velocity into the centres of no pressure of the water jets, advancing much more rapidly than the water can possibly flow, penetrates the cushions of compressed air without resistance and without work being performed, hence no heat." Pursuing the theory that the interaction of gas, liquid, and solid could be made to perform work under the slightest disturbances of equilibrium, Mr. Gamgee designed tubes by which he was enabled to secure currents of great velocity under all pressures at which liquids might be boiled; in other words, steam boilers in which the circulation diminishes with increase of pressure could be constructed, so that convection of the fluids would occur with equal facilities, whatever might be the steam pressure required. Each tube is practically an automatic pump, and consists of a cylindrical envelope, closed at both ends, but provided with an admission tube to permit the fall of water to the most recumbent point, and another tube projecting upwards, beyond the liquid level, so as to discharge the steam and water into the steam space.

The extension of this forced circulation beyond the interior of a boiler and through any length of tubing, led to the invention of the Cardium.

It was only on the 2nd of August, after protracted investigations with metallic cardia, that Mr. Gamgee succeeded in finding a glass-blower, Mr. Alfred Dean, jun., whose skill was adequate to making the most complex forms of apparatus which may be taken to represent the original idea of a prime mover—the animal cell. Mr. Gamgee exhibited metallic triple tubes whereby forced convection could be attained, and he likewise exhibited a metallic cardium with a closed circuit of tubing to illustrate how boiling water might be pumped any distance and returned to a cardium.

The most important apparatus—a new philosophical instrument—the glass cardium, consists of hermetically sealed chambers and tubes so related to each other that when from any adequate circumstance the equilibrium is disturbed, gas forms in the main vessels, projects the liquid, fountain-like, into one or more upper chambers and the gases, liquefying as fast as they discharge, ensure the returning falling column of pure liquid to re-commence the cycle. Mr. Gamgee pointed out that the thermometer and Dr. Wollaston's cryophorus or frost-bearer might be regarded as leading up to the new apparatus in which the dynamics of a material system might so well be studied.

If we open a treatise on heat, as for instance, Balfour Stewart's, we must be struck by the fact that *a priori* the cardium is an impossible machine. The condensation into liquid should be attended by a considerable evolution of heat. Condensation of a gas on the surface of a solid is said to produce heat, and Pouillet has shown that heat results from capillary action. Without external cooling the progressive production of gas should raise the pressure and temperature so as to arrest liquefaction, and the beautiful action, which would be found continuous for any time. Is it not quite evident that on the heat entrance and heat exit assumption, we are landed by the cardium on the horns of a dilemma? The liquid that should return to the bulb hot, feels colder and colder to the hand as the action continues.

Watching the action in some of the forms of apparatus, the salient concept formed is the dependence of the circulation on alternate gasification and liquefaction, on changes of form of the fluid contents, or what we may correctly name *metaphysis*, *change of form*, or *change of state*, and *metastasis*, or *change of place* or *relative position*—in one sentence, to use Forster's word as applied to the living organism, work depends on metabolism.

William Harvey devoted twenty-six years and more to the demonstration of the compulsory movement of the blood in a closed circuit. He published his results in 1626. In 1661, Malpighi discovered the capillary circulation and the presence of blood globules within the vessels. Since then the real cause of the flow of fluids in plants and animals has practically remained a mystery. We all believe that the heart pumps the blood through our arteries and veins. And what, then, pumps the blood through the heart itself? The Cardium shows that gasification, the ready absorption of unaltered oxygen by the the blood in the animal or of the carbonic acid in the plant, entirely account for the automatic circulations only regulated and not produced by pulsatile organs.

In man, the blood columns balanced everywhere, and the peculiar properties of spurting blood, always aërated, render the effort to maintain the circulation so slight, that pathological anatomists who dissect ossified and fatty hearts or anidian monsters which are always acardiac, and comparative anatomists who investigate the circulation in the leech or sand-worm, cannot wonder that, so long as life lasts and respiration continues, the circuit must be traversed for the purpose.

A cardium, for the first time in the history of machines, illustrates the *vis a fronte.*

The oxygenation of blood is the prime factor in the cardiac and arterial impulses—the true and only efficient agency in maintaining circulation — the indispensable and primary function of the animal economy.

An animal is an engine whose structure has to be renewed, without intermission, from birth to death. That renewal demands food and assimilation. When physiologists and engineers compare aliment to the fuel of the steam-engine, they err. An animal is not a heat-engine.

The apparatus before us in every form is remarkable for the rythmic impulses, the pulsations, which are not controlled by a contractile heart, but illustrate that any circulation in a prime mover so constituted must be intermittent, however slight and insignificant the intermission, owing to the Newtonian principle of action and reaction.

It is worthy of special remark that the invention of novel means of observation such as the thermometer, barometer, telescope, microscope, and others too numerous to mention, are of infinitely greater importance in the advance of true philosophy, than the new ideas and theories of the profoundest thinkers who must first be rigid experimenters.

Leibnitz, it is true, gave us a clue of enormous importance by his law of continuity, without which the action of the cardium, and indeed the relations of every phenomenon would to-day be quite inexplicable.

The natural link between physical considerationsrelating to the cardium and chemical theory, is readily comprehended, if we consider "nascent actions." As Mr. Pattinson Muir cogently remarks, chemistry is not the study of this element or that, regarded as a kind of matter with certain fixed physical properties, but the processes of change are the subject matter of the sciences, and to explain any one ot these we must take into account each and all of the re-acting bodies, and each and all of the conditions under wich the total change is proceeding.

Heat is that state produced by work done on a body such as friction, torsion, hammering, &c., and sound philosophy refuses to consider "effect" as at the same time cause and effect too. As Carnot said in his posthumous notes, "Heat is a destruction of motive force."

Mr. Gamgee wishes distinctly to state that there is no more earnest believer than he in the great principle of conservation, but, when we are told that the greatest achievement of this century is the doctrine of conservation of that energy which is the product of a force into space, he confesses that he is bewildered by the implied idea of conservation of space, as indeed by the other implied idea of conservation of time.

No individual substance has within itself the power to move another. As Judge Stallo said, "A constant central force, as belonging to an individual atom or molecule or object in and by itself is an impossibility." "No mathematician," said Professor Clifford in 1873, "can give any meaning to the language about matter, force, inertia, used in current text-books of mechanics."

An organism is a typical prime-mover. Without it there is no atmosphere and no gaseous elasticity. Without air there can be no water circulation, and without falling rains, no wind and no solution of organic and inorganic products for nature's system. Each organism is composed of solids to sustain and direct, of liquids to flow, and permeating gases with power of indefinite expansion.

The simple nature of this action and reaction is brought about by liquid and solid bodies flowing and falling from higher to lower levels, and the atmosphere incapable of restraint by virtue of its elasticity.

The source of the atmosphere and its enormous capacity for disturbing equilibrium is life. Without living organisms there can be no elastic air. Without life there is no work, and the great principal of work underlies all and dominates the universe as a whole.

The ancients discovered the true grounds of the doctrine of equilibrium. Work is the natural and inevitable result of every disturbance of equilibrium. This I have proclaimed for ten years past. It involves no waste, and is universally diffused and operative.

Electrolysis is a phenomenon observed when a prime mover induces by work and in suitable apparatus the decomposition of electrolytes.

Thermolysis, or so-called dissociation by heat, is invariably the result of complex inter-action of bodies, as when gases and liquids or vapours like steam are passed through intensely heated tubes. Work must be performed, and what I wish to enforce is a lesson that I am not certainly the first to read to a scientific audience, and which Clifford and others have eloquently expounded, namely :—"That the expressions matter and force, or its co-relative energy, have been used in physics in a manner not warranted by our knowledge of nature's method." There are no natural forces. There are none to discover.

I confess that the persistence with which mathematicians build their speculations on the assumption of kinetic theories simply amazes me. Stallo points out that the physicist who insists on impact theories of gravitation, cohesion, or chemical affinity, has the same intellectual blood in his veins which coursed in those of the old disputants about "first matter" or "substantial forms."

Hirn showed in 1882 that the kinetic interpretation of the construction of gases generally was not reconcilable with the inevitable conclusion from his experiments, namely, that the resistance of air to the movement of bodies is not a function of temperature.

"Oculos habent sed nolunt videre," said Hirn. "How is it," he asks, "that so many insist on recognising the cause of motion as motion." It is, in my opinion, impossible to reconcile the phenomena attendant on the interaction of fluids in the cardium to any Kinetic theory.

We have exhaustive mathematical treatises on the dynamics of a material system—the assumptions which have satisfied the most skilful theorists will have to be modified in the presence of the one material system, which is the type of all capable of independent motion under the influence of external work. The glass cardium is the transparent type of all that illustrates the law which I have no hesitation to proclaim, and which time will prove valid, namely, that work depends on the struggle for change in the in-organic, as in the organic world, affecting all bodies as parts under restraint in a boundless environment—the Universe.

A NEW ACTINOMETER.

Dr. A. **Richardson** explained to the section a new form of self-registering actinometer, and was thanked for so doing.

COLOUR-BLINDNESS.

Mr. **Baynes**, the recorder (in the absence of Mr. J. Spiller), read a paper on "An Experiment in Colour-Blindness." Before proceeding to describe his experiment, Mr. Spiller mentioned that he had good proof of his being blessed with the possession of a normal sight, for in the course of a long experience with coal-tar colours, and having frequent occasion to compare observations in regard to slight differences of tint with six colleagues, he had never perceptibly deviated from the consensus of the laboratory staff, and might fairly claim to be reliable on this score. He said that the examination of several colour - blind persons had convinced him of the practical value of a compound tassel of green and grey silk as a preliminary indication of defective colour vision. He felt desirous of trying an experiment to see whether it was possible by the administration of a small dose of santonine to realise the imperfections of vision which seemed common to most colour blind persons. He took fasting a small dose of santonine, a grain and a half dissolved in a small quantity of alcohol, and diluted with water. In less than five minutes the dose took effect ; the whole tablecloth appeared of delicate bluish colour, and all objects were seen as strange spectacles of the tint. He went into the garden to use his spectroscope, and could see all the solar rays in unbroken series with scarcely perceptible variations. There was no actual grey band in the green, but this portion of the spectrum appeared normal and splendidly brilliant. His condition, however, was not so abnormal as many of his colour blind friends. He, however, had to use a word of caution. He only took a quarter dose, but his condition was so serious that he feared the worst consequences, and had to take an emetic of mustard and warm water to give him relief.

Mr. Spiller was thanked for his paper.

TAKEN AS READ.

In the absence of Mr. J. Hancock, his paper, on "A Mode of Photography," was taken as read.

PHOTOGRAPHIC NEGATIVES.

Mr. **Walter Gardiner** read a paper on "A New Method of Printing Photographic Negatives, Employing Living Leaves in place of Sensitive Paper." The author dwelt upon the well known fact that the whole of the animal life upon the globe depends directly or indirectly upon the wonderful synthetic formation of proteid and protoplasm which takes place in the living tissue of plants containing chlorophyll, *i.e.*, green plants, or to be more exact, in the green chlorophyll corpuscles. He stated that whatever is the exact chemical nature of the process, this is at least clear that the first *visible* product of the assimilatory activity is starch, which, moreover, is found in the chlorophyll grains. The presence of this starch can be made manifest by treating a decolorised leaf with a water solution of iodine. This formation of starch only takes place under the influence of light ; the radiant energy of the sun providing the means of executing the profound synthetic chemical change and building up proteid from the carbonic acid of the air which is taken up by the leaves and the salts and water of the soil absorbed by the roots. If a plant (and preferably a plant with thin leaves) be placed in the dark overnight, and then brought out into the light next morning, the desired leaves being covered with a sharp and well developed negative, starch is formed when light is transmitted, and in greatest quantity in the brightest areas. Thus a positive in starch is produced which can be developed by suitable treatment with iodine. A leaf was then developed, and handed round to the audience for inspection. The author showed that it might be possible to obtain a permanent print by suitable washing and treatment with a soluble seived salt, seived iodide being formed. The author regards this discovery as a most striking illustration of the way in which plants are working for themselves, and so for all living things, and points out that the extraordinary manner in which the green parts of plants, so to speak, catch the radiant energy of the sun, and employ it for analytical and synthetical chemical processes, may be easily and clearly demonstrated.

The author received the thanks of the section.

THE ACTION OF MAGNETISM.

Mr. P. Braham read a paper on "The Action of Magnetism on Photographic Plates." The following is an abstract of the paper:—During some investigations I was pursuing concerning magnetism, I surmised that photographic plates could be acted on by that force, but not having sufficient electrical energy at command to render the result clearly apparent, I waited until an opportunity occurred. A friend placed at my disposal a battery of sufficient power, and plates of great sensitiveness, with the following results:—By placing photographic plates between the poles of a powerful electro-magnet and intermitting the current, an action similar to that of light is produced, which on development shows a nebulous appearance in the part directly between the poles, and an intense spot at some distance from them. The magnet used was formed of a ring of soft iron with two solensids within the diameter; the poles of the solensids were within fifteen millimetres of each other. The plates first used are known as "Lumière."

THE CONSTITUTION OF COMETS AND METEORITES.

Mr. Braham also read a paper on "The Physical and Chemical Constitution of Comets and Meteorites," in which he said that, in accordance with recorded investigations, comets were extremely attenuated masses of gas with very little solid matter. Meteorites were solid masses of matter with very little gas. The evidence of the presence of carbon and hydrogen had been invariably found in the spectra of comets. In meteorites which had fallen the usual meteoric metals have been found, but the occluded gasses vary, and might be acquired during their passage through the earth's atmosphere after their fall. He ventured to intimate that the result of the formation of a solar system was an elipsoid of magnetic force, the major diameter being in the mean plane of the system with the poles at the extremities of the minor. He had every reason to believe that the gaseous constituents of a comet were aqueous vapours, carbonic acid, and nitrogen in variable porportions. The brilliancy of meteorites was due to the heat produced by friction during their passage through the earth's atmosphere.—Mr. Braham was thanked for his papers.

THE UNIFICATION OF TIME.

The committee appointed to consider proposals relative to the unification of time and the adoption of a universal prime meridian, which have been brought before the committee by a letter from the Academy of Science of Bologna, reported as follows:—Mr. Christie and Dr. Longstaff (neither of whom was present at the meeting at Bath) declined to serve on the committee. The remaining two members of the committee are of opinion that the question of a universal prime meridian is one that cannot usefully be considered by a committee of the British Association at the present time.—The report was received.

This concluded the business, and the Acting-President, in dissolving the section, hoped they might all be spared to meet again on another occasion.

SECTION C.—GEOLOGY.

EOCENE PLANTS OF THE ISLE OF WIGHT.

Mr. J. Starkie Gardner read a report on "The Eocene Plants of the Isle of Wight."

THE SO-CALLED CONCRETIONARY STRUCTURES IN LIMESTONE.

Professor A. H. Green made some remarks on "The so-called Concretions in the Magnesian Limestone of Durham." He casually remarked that his advice to young geologists was never to be satisfied with museums and collections, however valuable, but to go and see things in nature, as they were on their grander scale.

GEOLOGICAL SURVEY OF NORTHUMBERLAND AND DURHAM.

Mr. W. Topley read a report on the work of the Geological Survey in Northumberland and Durham, communicated by permission of the director-general. He said:—The geological survey of Northumberland and Durham was commenced in 1864 (the year after the last meeting of the Association in Newcastle) by Mr. Howell, who superintended the work until its completion. The following officers of the survey have, at various times, assisted in mapping the district:—Messrs. Barrow, Burns, Cameron, Clough, Goodchild, Gunn, Lebour, Miller, and Topley. The mapping has all been done on the 6-inch scale. Some of the 6-inch maps are published, others are deposited for reference in the Survey Office, London. All is reduced to the 1-inch scale. Of these maps two series are issued, one showing the glacial and other superficial deposits—"drift maps;" the other showing the rocks beneath the glacial deposits—"solid maps." There are also "horizontal sections" on the scale of six inches to a mile, "vertical sections" on the scale of forty feet to one inch; and memoirs explanatory of the various one-inch maps. An index map, on the scale of four miles to one inch, is in preparation. Silurian rocks are exposed in the higher valleys of the Rede and Coquet, and a small faulted inlier, hitherto unknown, has been discovered near Ingram. Few fossils have been found on the English side of the Border, but they are more numerous on the Scottish side, and fix the age of the beds as Wenlock. A small but important inlier of Silurian rocks was discovered by Messrs. Gunn and Clough in Teesdale, above the High Force. These beds belong to the Stockdale Shales; they are traversed by dykes of mica-trap. On the Yorkshire side of the Tees, near the same place, beds belonging to the volcanic series of the Lake District have been discovered. The Cheviot area has yielded some interesting results. The general structure of this region, and the age of its rocks were known to Mr. Tate, and the Geological Survey of Scotland worked out the details on the Scottish side before the English Survey had touched the English side. Indeed, the best general description of the district is that contributed to "Good Words" by Professor James Geikie in 1876. Granite has long been known to occur in the heart of the Cheviots, but its importance was not recognised until Mr. Teall showed that it contained augite, and hence belonged to a type of rock rather rare in Britain. The greater part of the Cheviot area has been mapped by Mr. Clough. The geological history of the district is briefly as follows: Over the floor of Silurian rocks porphyrite lavas and ashes were erupted; associated with the porphyrite there are small patches of lower old red sandstone and conglomerate. The porphyrites differ in no essential respects from rocks of tertiary age, the hypersthene, augite, and mica-andesites being all well represented; the horn-blende-andesites, however, are absent. Intrusive through the porphyrites are numerous dykes of felstone, quartz-felsite, and porphyrite; whilst the central area is occupied by a large intrusive mass of granite. The granite sends veins into the porphyrite, but is itself traversed by some of the veins of felstone, &c., just mentioned. The granite is, therefore, later than the main volcanic outburst of the district, but is earlier than some of the felstone and similar dykes. The dykes roughly point towards the central region, as though radiating therefrom. Mr. Clough suggests that some dykes which in the central area are granite become felstone or porphyrite dykes in their outward extension. The igneous rocks of the Cheviots are then approximately of the same age, the granite forming the core and central area of eruption. These igneous rocks are all earlier than the lowest carboniferous or upper old red sandstone, because the basement conglomerates contain fragments of Cheviot porphyrite and granite, whilst no porphyrite or granite dykes are known to enter the carboniferous rocks. The carboniferous limestone series of Northumberland is of considerable interest, and it affords the key by which the beds in Scotland have been correlated with the typical areas in central and southern England. As shown in a paper by Mr. Hugh Miller, read at the Birmingham meeting of the Association (report for 1886, p. 674), the classification proposed by the late G. Tate, of Alnwick, is applicable generally, with only slight modifications, to the whole of Northumberland. The groups are, in descending order :—Calcareous division, carbonaceous division, fell sandstone series, cement-stone series, lower freestones and basement conglomerates. The most striking physical feature is that at the base of the thick fell sandstones these rocks form a range of craggy moorland throughout Northumberland, much broken, however, by faults in many places. The top of the fell sandstones is less easily defined. The base of the calcareous division is taken at the Dun limestone, which is now known to be the same as the Redesdale limestone of the centre and south of the county. A well-marked horizon in the calcareous division is that of the great limestone, known as the 10-yard, and Dryburn limestone in North Northumberland. Workable seams of coal occur throughout the calcareous and carbonaceous division. The detailed mapping of the beds has enabled the survey to trace a great number of important lines of fault, the majority of which would have been unknown, or at least very imperfectly understood but for such survey. Amongst the special points of interest resulting from the survey of the limestone series the following may be mentioned: *(a)* A great part of the calciferous sandstone series of Scotland is the equivalent of the true carboniferous limestone of central England ; *(b)* The Scremerston coal seams must underlie the limestones in south-eastern Berwickshire ; *(c)* The same series of coals must be brought in by an important synclinal in the valley of the Till between Chillingham and Wooler ; *(d)* The Lewisburn and Plashetts coals are on the horizon on the Scremerston seams ; *(e)* The discovery of an important fauna and flora in the cement-stone series of Northumberland, hitherto believed to be but sparsely fossiliferous. Over sixty species, including twelve plants, have been collected. Several new plants have been described by Dr. Kidston. Eight new schizopod crustaceans, and two or more scorpions, have been determined by Mr. Peach. The true carboniferous limestone fauna is especially characteristic of the limestones of the calcareous division, the shales and the ironstones of that division containing genera peculiar to themselves. Some beds of limestone are much more fossiliferous than others, and locally may be characterised by special fossils ; but palæontology cannot be relied upon for fixing positions in the calcareous series. *Saccaminina Carteri*, supposed when first discovered to be confined to the four-fathom limestone, is now known to have a much wider range. The lowest beds of the carboniferous series are coarse conglomerates ; these are not continuous deposits, but seem often to have accumulated in sheltered hollows or bays. They are not always on the same horizon, but form local "basement-beds." That overlying the Silurian rocks of Teesdale is about 1,500 feet higher in the series than the basement conglomerate of the Cross Fell escarpment. The thickness of the various divisions varies much. The Fell sandstones attain their maximum thickness of about 2,000 feet at the Simonside Hills ; they thin to about 500 feet to the west and north. The carbonaceous series attains its maximum thickness of about 2,500 feet in North Tynedale ; the calcareous division its maximum (of about 3,500 feet) near the Wansbeck. The cement stone series is thickest west of Rothbury and again near the Tweed ; in both districts it is about 1,500 feet thick. The limestones of this series are most fully developed west of Rothbury. As regards the coal-measures the survey has, for the most part, merely been able to collect information from the mining engineers, and to trace the outcrops of the more important seams. The history of the coal-field was well worked out before the survey came into the district. Perhaps the part least known was that north of the Wansbeck, and even now there are areas here as yet only partially understood. One of the most important seams north of the Wansbeck is the Ashington or Longhirst main seam. This was shown by the survey to be the equivalent of the Grey seam. The late Mr. Cole, of Bebside, I afterwards found, was also of that opinion, which, however, was not accepted by other mining engineers. The highest coal-measures do not occur in the district; there is here a strong unconformity between the carboniferous rocks and the permian beds ; the latter in South Durham sweeping over the edges of the former until they rest on the carboniferous limestone. The occurrence of rock-salt in the lower part of the triassic rocks near the Tees is a most important point in the geology of the district, but that question is fully dealt with by Messrs. Marley and Lebour in another paper. Contemporaneous basaltic rocks occur in the lower part of the carboniferous limestone series in Liddlesdale, in Cottenshope, and near Carham; but they are better developed on the Scottish side of the Border. They lie between the lower freestones and the cement-stone series. The intrusive basaltic rocks occur in two forms—as "sills" and as "dykes." The sills are sheets of basalt, lying in and between the sedimentary strata in such a manner as to have led some observers to believe the beds of trap to be contemporaneous ; but evidence of intrusion is abundant elsewhere, and the basalt lies at very different horizons in different places. The whin sill usually occurs within the lower half of the calcareous division, but in North Northumberland it goes lower. In the south-west of the county, in the faulted coal-field of Midgeholm, a sill of basalt occurs in the lower coal-measures. The age of the whin sill is not known; it is probably late carboniferous, or a little later. There is every reason to believe it to be pre-triassic. The basaltic dykes are of two ages; some seem to be of about the same age as the whin sill. Indeed. small local sills seem sometimes to have branched out from the dykes; and some dykes are apparently pre-permian. Other dykes are certainly much later, and no doubt belong to the great tertiary volcanic outburst, the general history of which has been lately written by the Director-General of the Geological Survey. Some of the dykes which preserve so long a course through the country, such as the Cleveland and the Acklington dykes, belong to this later series. The glacial and other drift deposits have throughout been mapped by the survey on the six-inch scale ; ice-marks and other phenomena connected with the glaciation of the district being also recorded. The higher summits of the Cheviots, and the high areas of carboniferous rocks to the south-west of these, are believed by Mr. Clough to have acted as independent centres of glaciation, and never to have been overridden by any general ice-sheet ; but all the rest of the country has been covered by an ice-sheet, coming from the west on the south side of the Cheviots, and from the north and north-west on the north and east of the Cheviots. The glacial markings and other phenomena connected with the drift give evidence of this.

CONCURRENT FAULTING AND DEPOSITING.

Mr. R. Tiddeman read a paper on "Concurrent Faulting and Depositing (Craven, Yorkshire), with a note on Carboniferous Reefs."

This concluded the business of the section, which rose shortly after noon.

GENERAL COMMITTEE OF THE BRITISH ASSOCIATION.

GRANTS FOR SCIENTIFIC PURPOSES.

A meeting of the General Committee was held at one o'clock in the afternoon, in the College of Medicine. The President (Professor W. H. Flower) was in the chair, and there was a small attendance.

The President explained that the object of the meeting was to receive the report of the Committee of Recommendations, and to afford to any member who wished to give notice of motion for the next meeting an opportunity of doing so.

Mr. A. G. Vernon Harcourt (co-general secretary) read the following synopsis of grants of money appropriated to scientific purposes by a Committee of Recommendations at the Newcastle-upon-Tyne meeting :—

Mathematics and Physics.—Differential Gravity Meter, £10; Electro-optics, £50; Calculating Mathematical Tables, £25; Seismological Phenomena of Japan, £75; Pellian Equation Tables, £15; Electrical Standards, £50; Electrolysis, £5.

Chemistry.—Properties of Solutions, £10; Analysis of Iron and Steel, £10; Isomeric Naphthalene Derivatives, £15; Silent Discharge of Electricity, £5; Methods of Teaching Chemistry, £10; Absorption Spectra, £30; Recording the Results of Water Analysis, £10; Oxidation of Hydracids in Sunlight, £15.

Geology.—Erratic Blocks, £10; Volcanic Phenomena of Vesuvius, £20; Fossil Phyllopoda, £20; Geological Record, £100; Underground Waters, £5; Excavations at Oldbury Hill, £15; Cretaceous Polyzoa, £10; Geological Photographs, £10; Lias Beds of Northamptonshire, £25.

Biology.—Botanical Station at Peradeniya, £50; Deep Sea Townet, £10; Naples Zoological Station, £100; West India Islands, £100; Marine Biological Association, £30.

Economic Science and Statistics.—Monetary Standard, £10; Precious Metals in use as Money, £15.

Mechanical Science.—Waves and Currents in Estuaries, £150; Graphic Methods in Mechanical Science, £15.

Anthropology.—North-Western Tribes of Canada, £100; Effect of Occupations on Physical Development, £20; Anthropological Notes and Queries, £50; Anthropometric Calculations, £10; Nomad Tribes of Asia Minor, £25; Natives of India, £10.

Coresponding Societies, £20.

The total is £1,265.

The President said the applicants had been very numerous this year, and it was with great regret that the committee were unable to agree to all the grants asked, but it was not because the committee were not fully aware that many of the grants asked for were for very valuable purposes. The grants were refused simply because there was not money enough for everything. They had gone, he thought, to their full extent in granting what they had done, considering the income of the association. The treasurer was not present, but he was not sure that the treasurer would approve altogether of what had been done, but there were so many applications, that it was impossible not to grant a considerable sum. If anyone was disappointed at not having any sum granted, he must remember that it was from want of means, and not from want of will on the part of the committee. He moved the adoption of the recommendations.

This was agreed to.

Sir Erasmus Ommaney (acting treasurer) said he believed the amount for the various committees had been granted according to their importance.

THE ATTENDANCES AT THE PRESENT MEETING.

Sir Douglas Galton (co-general secretary) announced the number of tickets issued up to the present time as follows :—

Old life members	277
New life members	20
Old annual members	412
New annual members	113
Associates	1024
Ladies	579
Foreign members	12
Total	2437

PUBLICATIONS.

The recommendation of a committee that certain papers be printed *in extenso* was referred to the council.

Professor Hull said the annual volume of Transactions was becoming very bulky. There were many other ways in which the papers could be published, and he thought it was unwise to enlarge the scope of the annual volume. (Hear, hear.)

The President said that was the reason why the Committee of Recommendations resolved to remit the matter to the Council.

In the case of some other papers, permission was given for them to be printed in full.

Several resolutions of committees were considered.

PHYSICAL EFFICIENCY.

On the recommendation of the Committee of the Anthropological Section, it was decided that action should be taken to induce the Government to give candidates for the public service marks for physical efficiency, as proposed by Mr. Francis Galton in a paper read before the section.

After transacting other business, the meeting adjourned till the Leeds meeting of 1890.

THE GENERAL COMMITTEE PHOTOGRAPHED.

At the conclusion of the meeting of the General Committee the members were photographed on the steps at the main entrance to the College of Medicine.

CONCLUDING MEETING OF THE ASSOCIATION.

VOTES OF THANKS.

The concluding general meeting of the association was held in the afternoon, in the St. George's Hall. Professor Flower, President of the Association, was in the chair, and there were also on the platform Sir Frederick J. Bramwell (ex-president), Sir Douglas Galton, Principal Garnett, Professor Merivale, the Mayor (Mr. Thos. Richardson), the Sheriff (Mr. Wm. Sutton), Dr. A. G. Nernon Harcourt, Dr. Philipson, Dr. Embleton, Dr. Wm. Anderson, Dr. R. S. Watson, Dr. Heath, Sir Geo. Elliot, and others.

The President said: I have to announce that the members of the association who have attended this meeting are :—Old life members, 277; new life members, 20; old annual members, 412; new annual members, 113; associates, 1,024; ladies, 579; foreign members, 12; total, 2,437. (Cheers.)

THE MAYOR AND CORPORATION.

Sir Fred. J. Bramwell said their first duty on such occasions as that was to return their thanks to the Mayor and Corporation of the town or city wherein the association met. His experience of the association was now one of very many years. But he was quite sure he was saying nothing but the bare truth when he asserted that on every occasion those thanks had been well earned and justly due. If that was the truth on every occasion, it was perhaps—if that could be so—more true on the present occasion. (Laughter and applause.) It was necessary for the success of the meeting that they should have a president to whom they could look with respect, and that they should have a large attendance of members, good papers in the sections, and good presidents and vice-presidents. He thought all these elements had been at the Newcastle meeting, and that in very considerable force and extent. But there was another most necessary element to a successful meeting, and that was that the place wherein they met should cordially receive them, and should be glad not only to have the members of the association with them, and extend their hospitality to them, but to have them for the sake of the science they were endeavouring to promote. He was certain that every member of the association would agree with him that in this respect the Mayor and Corporation of Newcastle had done everything that could possibly have been expected of them, and everything the association had received in any other town. (Applause.) Their appreciation of their meeting had been great, and their exertion to render the meeting successful had been great. He must not speak of their hospitality, because that would be mentioned by another speaker, at all events the hospitality of Newcastle generally. They had been most hospitably received in Corporation fashion, and they had had a spokesman of the Corporation, who, as a Mayor, was possessed in an eminent degree of urbane manners, of right views, and of the ability to express them in the most felicitous words as occasion arose. He had the honour to propose that a vote of thanks to the Mayor and Corporation of Newcastle-on-Tyne be given by that meeting on behalf of the association. (Applause.)

Mr. G. W. Hastings, M.P., in seconding the resolution, said they all of them had had reason to congratulate themselves on the hospitality and kindness that had been shown them in Newcastle-on-Tyne, and in seconding the vote of thanks to those who ruled the ancient borough, he would say that there was nothing he had observed for years past as more indicative of the progress in every part of the country than the wisdom and energy in administration which was shown by the municipal corporations throughout the country. It had fallen to his lot for a good many sessions of Parliament to have to conduct the proceedings of the committee to which all bills relating to municipal corporations were sent, and session after session he was struck by the wisdom and the persistence with which they strove for powers they required for the good of the people. He was quite sure that Newcastle-on-Tyne was as well governed as any borough which had come more immediately under his observation in that committee. The reception the Mayor and Corporation had given them had shown their sympathy and their desire for the improvement of the country at large. He had great pleasure in seconding the resolution. (Applause.)

The resolution was then carried by acclamation.

The Mayor of Newcastle (Mr. T. Richardson) returned thanks. He said :—Mr. President and Gentleman,—On behalf of the Corporation of Newcastle and the citizens generally, I have to return thanks for this vote which you have so cordially passed. I ventured on the first meeting here, on the occasion of the President's address, to offer to you a very cordial Newcastle welcome, and I think perhaps your experience now will have confirmed the truth of that observation. (Cheers.) For the personal kindness which I have received from the President and all his associates, I am deeply grateful. If there has been any fault in my part of the proceedings, it is due to my inexperience and not to any want of will. (Cheers.) I most sincerely thank my brother "lions" for the honour they did me last evening in admitting me into their society. (Laughter.) I see a look of curiosity pervading the countenances of all the ladies, as though they were wishful to have interpreted to them those mysterious initiatory rites through which I passed last night. (Laughter.) Not only is the seal of silence upon my lips, but I am bound further to say that those rites were so awful and so mysterious that language would fail me to describe them. (Continued laughter.) I sincerely hope that by the next meeting of the Association, at Leeds, I shall have so far advanced in knowledge as to be more proficient both in my leonine manners and general attitude. (Laughter and cheers.) Allow me, in conclusion, to express—and I do this on my own behalf, and I believe, on behalf of the citizens—the most heartfelt wishes for the prosperity of the British Association, wishing, for instance, that those intrepid travellers who have favoured us with their presence and their splendid addresses on this occasion, and who are again going out on visits of exploration, may have health and protection afforded them in their grand and noble work. (Cheers.) Allow me also to express the hope that the men of science around us may have the same health and strength vouchsafed to them to enable them to pursue their arduous labours ; and in conclusion allow me to wish to the visitors a very safe journey to their respective homes, and to one and all an affectionate farewell. (Loud cheers.)

The Sheriff (Mr. Sutton) said he was sure the remarks of Sir Frederick Bramwell would be re-echoed by that meeting—that was, the admirable way in which the Mayor could express his thoughts. Everything that had been done in Newcastle had been done with good will, and with a desire to make the meeting successful, and, if that had been the result, they were very thankful, and had got all they desired.

THE MEETING PLACES.

Professor Rucker said he had to propose a resolution of thanks for services of great moment which had been rendered to the association during the present meeting. Those who were regular attenders at the meetings of the association knew that there was no more important consideration in the choice of a town in which the meetings were to be held than that there should be provided rooms suitable for the meetings of the sections and for the larger gatherings which were to be brought together to hear evening lectures, &c. In this matter the luxuries of one year became the requirements of the next, and year by year the standard of what they looked for in this matter rose. The provincial colleges, of which those of Newcastle were among the earliest to be founded, and among which they took one of the highest places, were now able to provide adequate accommodation for scientific experiments. The list of individuals and institutions, which he held in his hand was a long one, and it showed them how widespread the feeling of welcome to the British Association had been in Newcastle, how it had extended from the Mayor and Corporation, who had just received special thanks, to individuals and to bodies of all sorts, connected with religious denominations of various kinds, who had come forward to do what they could to welcome men of science in their midst. He moved the following vote :—

> That a vote of thanks be passed to the members of the University of Durham College of Medicine, to the Council of the Durham College of Science, to Mr. James Deuchar, proprietor of the new Assembly Rooms, to the authorities of the St. James's Congregational Church, to the authorities of the Gresham Place Presbyterian Church, to the authorities of St. Mary's Place Presbyterian Church, to the Public Library Committee of the Corporation, to the Committee of the Natural History Society of Northumberland and Durham, to the Council of the Newcastle-on-Tyne Church School for Girls, for the loan of rooms for the use of the Association.

Dr. Gladstone seconded the vote, and said they had been admirably entertained. But he thought they need not confine their thanks simply to those things which were necessary for their own convenience. He had known the Association for a great number of years, and could look back upon arrangements where they had to put up with comparatively poor accommodation. Newcastle had struck him as being altogether different. Enumerating the rooms that had been placed at their disposal, he said the Library was one of the finest in the kingdom, and was made a model for libraries all over. (Applause) There was also the Museum, with its unique collection of fossils and birds. They must congratulate themselves upon the accommodation that had been afforded to them in this city. It showed them that the citizens of Newcastle were determined in future to pay increased attention to science, and they deserved the best thanks, the cordial thanks, for the way in which they had received them, and for the various ways in which their conveience had been attended to. (Applause).

The President said it was an evidence of the wonderful advance of Newcastle. When the Association met in Newcastle in 1863, not one of the buildings which they had been using during the present week was in existence—all had been built since.

The vote was carried with acclamation.

Dr. Heath replied to the resolution. Speaking on behalf of the Durham College of Medicine, he said nothing could have given them more satisfaction than that their new college should have been occupied by the members of the British Association. (Hear hear.)

Professor Mertz acknowledged the vote of thanks which had been passed to the Council of the College of Physical Science. He spoke of the honour which had been conferred upon the college by the presence during the last six days in its rooms of so many illustrious members of the British Association. (Hear, hear.) The college was not yet finished. No doubt by the time the association next visited Newcastle the many defects which were now noticeable would be remedied ; and that they would have the want of the neighbourhood for scientific instruction more completely provided for, and that, through an increased liberality of the public, they would not have to offer for the use of the association a portion of the building, as had been the case at this meeting, but that they would be able to offer them a complete building. He also hoped that they would be able to show that the college carried on its work on a much larger scale than at present.

HOSPITALITY.

Sir **Wm. Thomson** said he hoped he was expressing the feeling of the assembled members when he said they had all profited by the hard work and by their attendance at the various sections of the past meeting. (Applause.) As an old member of the association, he might say that they (the older members) looked forward to the meetings of the association expecting to learn and not merely to teach. The social portion of the meeting had been of an admirable description, and only an hour ago a member had said to him, "the social occasions of the meeting were after all the most delightful of the whole affair." (Laughter and applause.) The work of the association have been exceedingly well promoted by the hospitality they had received in Newcastle—(applause)—not only in Newcastle, but the neighbourhood, far and wide. They were much indebted to those who had thrown open their works for the visits of members of the Association, and to those who had thrown open their clubs for the convenience of members and visitors, and to many others. It was through their efforts to a great extent that the meeting had been so prosperous and happy. (Applause.) He moved :—

> That the British Association cordially thanks the University of Durham and the Corporations of Berwick, Middlesbrough, and Morpeth, for their hospitable reception of those members of the Association who have visited the several centres to which excursions have been arranged (this must be made to include those who receive to-morrow's excursions), the Literary and Philosophical Society, and the other scientific and learned societies and the clubs of the city who have granted the privilege of membership to the Association, and those who have thrown their works open to the visits of our members.

Mr. **W. Anderson**, D.C.L., M.I.C.E., president of the G Section, seconded. He was glad to have the opportunity afforded him of seconding the resolution which Sir William Thomson had just laid before them. He was glad on several grounds. In the first place, he considered himself a citizen of Newcastle, and although he had left it for very many years, still he always hailed from Newcastle, and considered himself as belonging to that town. (Cheers.) He therefore naturally felt proud that the citizens of Newcastle had come out so strong—to use a popular expression—in their endeavour to accord a fitting reception to the British Association. In the next place, he was glad of the opportunity, because he thought, as president of one of the sections, he had had unofficial opportunities of judging how very sincere and earnest those who were charged with the arrangements on behalf of the town had been to promote the happiness and the welfare of the visitors to Newcastle. It had been quite evident, from his intercourse with them, that their sole desire was to make the meeting as successful as it could possibly be. Then he had also the opportunity of judging of the hospitality which had been extended by private individuals, for he himself had been the guest, with many others, of the citizens of Newcastle, and had heard on all sides how much hospitality had been extended, both public and private, in all directions. With respect to the University of Durham, he had not the opportunity of speaking, when, together with all the leaders for the time-being of the association, the University conferred upon them the highest distinction in their power. He was then only able to make a bow with credit, but now he was glad of the opportunity of showing how much he and those who received the degree appreciated the honour they had done to the association in the persons of the recipients. For all these reasons they would, he thought, agree with him that he was entitled to call upon them to respond to the resolution with the utmost fervour. (Loud cheers.)

The resolution was then put and carried amid cheers.

Dr. **Thos. Hodgkin** returned thanks for the resolution. He was sure the name of Lord Armstrong was in the minds of all of them. His lordship's hospitality had been most princely. Those meetings were very interesting, but they were also, in one sense, a little disheartening, because one felt that there was an intellectual treat spread out before him to which he was unable to do justice. He hoped the members of the association would not estimate the hospitality of Newcastle by what had been done, but would consider that the will had been much greater than the power. They had been told that the people of Newcastle had been sounding their own trumpet a little—(a Voice: "Hear, hear")—as if there was no such place as Newcastle. He felt deeply humiliated by all he had listened to when hearing the speakers set forth things new and old. It had made him feel like an ignorant little charity boy. He thought the people of Newcastle should resolve to make a new start, and make themselves more worthy of that science which was daily increasing in their midst. (Applause.)

Sir **Benjamin Chapman Browne** also returned thanks, and said he might not only reply on behalf of those who had thrown their works open, but also on behalf of the neighbourhood. Newcastle was a large town, and was the centre of a wide district, and the whole of the North of England was very anxious indeed to work together, and to co-operate in every good work, and there was nothing for which they were more anxious than to bring wise and influential people from all parts of the country and at all times, that they might learn from them, and that the visitors themselves might become acquainted with their industries. The programme of meetings had been so extensive as to prevent many of them from coming to see the works in the neighbourhood. Some had paid hurried visits, and, he hoped, some had derived pleasure from them. (Applause.)

LOCAL OFFICIALS.

Sir **Douglas Galton** moved a vote of thanks to the chairman, secretaries, and treasurer of the Local Committees, and the editors and the contributors to the local guides. He said in his experience—which was a long one—of the meetings of the British Association, he had on no occasion seen the rooms more satisfactorily arranged for the purposes of the meetings than on the present occasion. He thought he could also say that in every respect the Newcastle meeting bore the palm compared with almost any he had been present at. (Applause.)

Sir **Sydney Vines**, in seconding the resolution, said the arrangements for those excursions the members had already had had been excellent, and every possible effort for the comfort and convenience of the members had been made. They were much indebted for the use of the large public building already alluded to, and in many ways they were indebted to the Local Committee.

The resolution was carried with loud applause.

Dr. **Embleton**, replying on behalf of the committee, farther said that they had made every effort they could to have all they could for the convenience of the members of the British Association, and if there had been any shortcomings they were owing to circumstances over which the secretaries had no control. He was sure the next time the association came to Newcastle they would find better accommodation than they had had during the past meeting. He hoped the next time the association came they would have a new Town Hall—(applause)—in which they would be able to receive the association. (Loud applause.)

Prof. **J. Herman Merivale** (co-local honorary secretary) also returned thanks. He said that he could add nothing to what had been said by Dr. Embleton. He could only say that if the members were satisfied with the arrangements the local officers and committee were content. There was one he should like to say for the satisfaction of their guests, and it was to inform them that a great deal of unnecessary sympathy had been poured upon the local secretaries for the work it was supposed they had been doing during the meeting. It was not true that they had passed sleepless nights, and had been very much knocked up. They had enjoyed themselves immensely. They ntended to go with the excursions to-morrow, and were quite prepared to conduct the meeting in Leeds or that at Newcastle twenty-five years hence. (Laughter and applause).

PRIVATE HOSPITALITY.

Admiral Sir **Erasmus Ommanney** moved a vote of thanks to the noblemen and gentlemen who had given private hospitality to the members of the Association.

Dr. Hy. Woodward seconded the resolution, which was enthusiastically carried.

Dr. R. Spence Watson responded. The difficulty he laboured under in responding to the toast was the fact that everyone of them from the highest to the humblest, who had had the pleasure of receiving the distinguished persons who had visited Newcastle upon that occasion must have felt that to be a great privilege. He hoped the members would go from Newcastle with the feeling that, though the climate of that place was cold, the hearts of its people, like its coal, were warm. (Cheers.)

Dr. Philipson said he supported Dr. Watson in all he had said.

THE PRESIDENT.

Mr. H. H. Howorth, M.P., proposed a vote of thanks to the President (Professor Flower) for the way in which he had conducted the meeting. He had proved to the utmost not only his power of work but also his power of induction. Since the days of the prophet Jonah no one had made such a close acquaintance with and inspection of the internal parts of whales—(loud laughter)—as their president. He asked them to accord to one of the most scientific of men and one of the most chivalrous of gentlemen a hearty vote of thenks. (Loud applause.)

The Mayor seconded the resolution, which to his mind was the best text of that afternoon. They were going to pass a vote of thanks to the president for his invaluable address on the opening session, his subsequent addresses, and his general conduct of the association. He was sure they would record their hearty appreciation of him as a man of science, and for his high personal character, as well as his unfailing courtesy. (Cheers.)

The President, who was received with applause, said that, before he endeavoured to express to them his thanks for what had just been done for him, he must bring before them a small matter of business connected with the association. Mr. Howorth had referred to an address which was presented in that room on Saturday evening last by certain societies connected with this neighbourhood. That address was not presented to him personally and alone, but it was presented to the whole of the British Association, and until that general meeting he had had no opportunity of bringing it before the association. There was something so extremely interesting and pleasing in the circumstances under which it was presented, and in the wording of the address, that he felt that it ought to be brought before the members of the association. (Applause.) Having read the address, he said it was quite true that the honour of being president of that association was one that every scientific man must highly value. But it was an honour that, as he had lately found out, brought with it many attending circumstances that did not fall upon presidents in former years. Owing to the extreme energy of their friends of the press, the fierce light that beat upon a throne certainly extended and shed its rays also upon the president as well as upon other members of the association. If a man wished to see himself as others saw him he had better try to become president of the British Association. (Laughter.) During the last week he had not studied the papers, —he had not had time—but now and then he had taken them up, and he had seen a great many interesting personal observations upon himself and his friends. They had been described in all their aspects. Not only had the papers described the colour of his hair as it was at present, but also speculations had been made as to what the colour of that hair was in former times. (Laughter.) If one wanted to know oneself, however, some of the observations were a little embarrassing. They did not always coincide one with the other; whether this depended on the political character of the paper or not, he could not say. He had read in one paper that the president's voice was loud, and his elocution good, and he had read in another that his voice was soft and low, a very excellent qualification in a woman, but not so desirable in a President of the British Association. (Laughter.) There had been a great deal more that was not only interesting, but highly educational. Apart from these interesting circumstances connected with the office of President, he had also, he was sorry to say, especially that afternoon in the speeches of Mr. Howorth and the Mayor, aeceived a great deal of commendation he did not deserve in the least, but, however, they had to put up with that sort of thing as they went through life. (Laughter.) There was one particular part of it that he must disclaim. From the remarks made, some of them might have carried away the idea that the credit of the admirable arrangement and improvement that had taken place in the museum with which he was connected at London were due to himself. That was the last thing he would like any one to think. He did claim some credit of the administration of the museum of the Royal College of Surgeons for twenty-two years, and credit had been given him fully for it. But when he was appointed to the Natural History Museum, he found it already in a high state of organisation, and administered by most able officers, one of whom he was glad to see on that platform. (Cheers.) He could not conclude without expressing his heartfelt thanks to three persons. They had heard a great deal of praise of the Newcastle people and thanks being given them all round, and he was glad to be able to echo every word of it. It was impossible to pick out names, but he desired particularly to mention Lord Armstrong. (Applause). That was one of the advantages of meetings of that sort—the coming into contact with persons that otherwise would not be known to them. The next he would mention was the Mayor. (Applause.) They had heard all through the meeting the highest encomiums of the Mayor both in regard to the association and the municipality. The next was Professor Merivale. (Applause.) He did not wish to particularly mention the name amongst the other secretaries, but he must refer to the kind and most considerate manner of endeavouring to meet all his (the speaker's) wishes. He returned thanks to the mover and seconder for the kind terms in which that resolution had been moved, and to the audience for receiving it so heartily, (Loud applause).

The President then intimated that the general meeting was adjourned, and that the next annual meeting would be held at Leeds next year.

ATTENDANCES AND RECEIPTS AT ANNUAL MEETING.

The following is a table showing the attendances and receipts at the annual meetings of the association from the commencement in September, 1831. It will be noted that in some years the totals do not appear for some reason or other to have been arrived at, and consequently cannot be given :—

Date of Meeting.	Where held.	Presidents.	Total Attendance.	Amount received
1831, Sept. 27	York	The Earl Fitzwilliam, DCL	353	—
1832, June 19	Oxford	Rev. W. Buckland, FRS	—	—
1833, June 25	Cambridge	Rev. A. Sedgwick	900	—
1834, Sept. 8	Edinburgh	Sir T. M. Brisbane, DCL	1298	—
1835, Aug. 10	Dublin	Rev. Provost Lloyd	—	—
1836, Aug. 22	Bristol	The Marquis of Lansdowne	1350	—
1837, Sept. 11	Liverpool	The Earl of Burlington, FRS	1840	—
1838, Aug. 10	Newcastle-on-Tyne	Duke of Northumberland	2400	—
1839, Aug. 26	Birmingham	Rev. W. V. Harcourt	1438	—
1840, Sept. 17	Glasgow	Marquis of Breadalbane	1353	—
1841, July 20	Plymouth	Rev. W. Whewell, FRS	891	—
1842, June 23	Manchester	Lord Francis Egerton	1315	—
1843, Aug. 17	Cork	The Earl of Rosse, FRS	—	—
1844, Sept. 26	York	Rev. G. Peacock, DD	—	—
1845, June 19	Cambridge	Sir J. F. W. Herschel, Bt	1079	—
1846, Sept. 10	Southamptn	Sir R. J. Murchison, Bt	857	—
1847, June 23	Oxford	Sir Robt. H. Inglis, Brt	1320	—
1848, Aug. 9	Swansea	Marquis of Northampt'n	819	707
1849, Sept. 12	Birmingham	Rev. T. R. Robinson, DD	1071	963
1850, July 21	Edinburgh	Sir David Brewster, KH	1241	1085
1851, July 2	Ipswich	G. B. Airy, Astro. Royl	710	620
1852, Sept. 1	Belfast	Lieut.-Gen. Sabine, FRS	1108	1085
1853, Sep. 3	Hull	William Hopkins, FRS	876	903
1854, Sep, 20	Liverpool	Earl of Harrowby, FRS	1802	1882
1855, Sep. 12	Glasgow	Duke of Argyle, FRS	2133	2311
1856, Aug. 6	Cheltenham	Pro. C. G. B. Daubeny, MD	1115	1098
1857, Aug. 26	Dublin	Rev. Humphrey Lloyd, DD	2022	2015
1858, Sep. 22	Leeds	Richard Owen, MD, DCL	1698	1931
1859, Sep. 14	Aberdeen	H. R. H. The Prince Consort	2564	2782
1860, June 27	Oxford	The Lord Wrottesley, MA	1689	1604
1861, Sep. 4	Manchester	Wm. Fairbairn, LLD, FRS	3138	3944
1862, Oct. 1	Cambridge	Rev. Prof. Willis, MA	1161	1089
1863, Aug. 26	Newcastle-on-Tyne.	Sir W. G. Armstrong, CB	3335	3640
1864, Sep. 13	Bath	Sir Chas. Lyell, Bart. MA	2802	2965
1865, Sep. 6	Birmingham	Prof. J. Phillips, MA, LLD	1997	2227
1866, Aug. 22	Nottingham	Wm. R. Grove, QC, FRS	2303	2469
1867, Sep. 4	Dundee	Duke of Buccleuch, KCB	2444	2613
1868, Aug. 19	Norwich	Dr Jos. D. Hooker, FRS	2004	2042
1869, Aug. 18	Exeter	Prof. G. G. Stokes, DCL	1856	1931
1870, Sep. 14	Liverpool	Prof. T. H. Huxley, LLD	2878	3096
1871, Aug. 2	Edinburgh	Prof Sir W. Thomson, LLD	2463	2575
1872, Aug. 14	Brighton	Dr W. B. Carpenter, FRS	2533	2649
1873, Sep. 17	Bradford	Prof A W Williamson, FRS	1983	2120
1874, Aug. 19	Belfast	Prof. J. Tyndall, LLD, FRS	1951	1979
1875, Aug. 25	Bristol	Sir J. Hawkshaw, CE, FRS	2248	2397
1876, Sep. 6	Glasgow	Prof. T. Andrew, MD, FRS	2774	3023
1877, Aug. 15	Plymouth	Prof. A. Thomson, MD, FRS	1229	1268
1878, Aug. 14	Dublin	W. Spottiswoode, MA, FRS	2578	2615
1879, Aug. 20	Sheffield	Prof G J Allman, MD, FRS	1404	1425
1880, Aug. 25	Swansea	A. C. Ramsay, LLD, FRS	915	899
1881, Aug. 31	York	Sir J. Lubbock Bart, FRS	2557	2689
1882, Aug. 23	South'ptn	Dr. C. W. Siemens, FRS	1253	1286
1883, Sep. 19	Southport	Prof. A. Cayley, DCL, FRS	2714	3369
1884, Aug. 27	Montreal	Prof. Lord Rayleigh, FRS	1777	1538
1885, Sep. 9	Aberdeen	Sir L. Playfair, CB, FRS	2203	2256
1886, Sep. 1	Birm'ghm	Sir J W Dawson, CMG, FRS	2453	2532
1887, Aug. 31	Manch'str	Sir H. E. Roscoe, DCL, FRS	3838	4336
1888, Sep. 5	Bath	Sir F. J. Bramwell, FRS	1984	2107
1889, Sep. 11	Newcastle-on-Tyne	Professor Flower	2437	2441

DEBATE ON WOMEN'S DRESS.

HIGH HEELS AND TIGHT LACING.

In the morning, in connexion with the British Association in Newcastle, Mrs. Stopes delivered a lecture in the Lecture Theatre of the Literary and Philosophical Society, Newcastle, on "Errors in Women's Dress." There was a very large attendance, principally of ladies. The gentlemen present numbered hardly more than a dozen. Dr. Philipson presided, and there were also present the Mayor (Mr. Thomas Richardson) and the Sheriff of Newcastle (Mr. Wm. Sutton).

The CHAIRMAN, in opening the proceedings, said: Ladies, Mr. Mayor, and gentlemen,—At the request of my friend, Sir William Turner, I have consented to preside on this occasion, at an assembly at which Mrs. Stopes will favour us with an address upon "Women's Dress," considered physiologically and psychologically. This is a very important question, and from this large assembly I gather at once that it is a question that has not only excited interest in the minds of many, but that possibly many have come to hear from this accomplished lady much that will be of interest and of value respecting dress. I should not wish to anticipate Mrs. Stopes in any way, but I may venture to say that, from the title of the paper, this question will be considered physiologically and psychologically, that it will be upon the basis of the preservation of health, which we all aim at, which we have at heart, which we know the importance of. I should also explain that this paper was prepared for one of the sections of the British Association for the Advancement of Science; but, on account of the Biological Section being limited in its scope, there being no sub-section of physiology, the authorities thought that it would be better, more proper, for this paper to be presented at a meeting in this Lecture Hall rather than in one of the sections. I offer this as an explanation. With this explanation, I shall now introduce to you Mrs. Stopes, who will now favour us with the address which has been prepared. (Applause.)

Mrs. STOPES, who was received with applause, proceeded to read her paper on the psychological, physiological, and physical aspects of dress. She said :—The origin of "dress" is complex, and its development depends not only upon the advance of civilisation, but upon the geographical position of the wearer in respect to the sun.

SAVAGE ATTIRE.

In torrid zones, among early savage peoples, the idea of "dress" is simply decorative, and, therefore, is based upon their crude notions of art, expressed in colouring or tattooing their bodies, and decorating it with shells, beads, feathers, and light articles of dress that can be found or easily made. One must pass beyond the tropics, and into older civilisations, before we find even an overall linen garment used. This, while it does not prevent the opportunity of decoration, suggests through habit, an idea of modesty. But to the typical man in hot climates the fundamental idea is art.

In the far North, savage man approaches "dress" in a different spirit. The preservation of animal heat is necessary to his existence; clothing is a movable covering and shelter. Warmth being the chief end sought, clumsy skins, rough hair or woollen cloths are the chosen materials; the fundamental idea is utility. The constant use of clothing elaborates the notion of modesty as an associated idea. After a period of successful development, the natural desire of decoration appears. Art is permitted in a subservient position to utility. Finer furs are sought, more graceful shapes, more brilliant decorations, from teeth, shells, feathers, horns, to brighten the sombre hues. Northern man, even if started in life at the same time, would pass over the first steps of civilisation more rapidly than his southern compeer. Vegetation does not come to his aid unsought; a hard battle has to take place with the animals for the sake of their skins and furs, as well as for their flesh. The difficulties in gaining these act as an intellectual training; energy is developed more in cold than in torrid latitudes. Yet the intellect absorbed in utilities, forms art ideas more crude and more grotesque, more based on mere rivalry in extent of possessions. The success which gives to the southern one finer feathers, gives to a northern hunter finer furs.

Between these two extremes, there lies the golden mean. The temperate zones share the advantages of each. The necessity of retaining heat through their changes of temperature has taught their inhabitants the utility of clothing. The rigour of their winters are, however, not overpowering; their summer suns not too enervating to destroy their courage and will; and yet vivid enough to wake in their souls the love of nature, and evoke dreams of art expressed in their dress. Notions of modesty are associated with its constant use. Dress is to them both useful and ornamental, or at least it is intended to be so, and can be so.

THE TYRANNY OF FASHION.

Through southern and northern races, through savage and civilised periods, the human race in regard to clothes has been swayed by other instincts than those of art and utility. Ambition to excel on the one hand, love of imitation on the other, have created a constant evolution. Custom rests the eyes, but variety refreshes it, and from the changes initiated to satisfy these human impulses, through the ages has developed an abstract tyranny, to which every one submits with a more or less submissive readiness—the tyranny of fashion.

The complexity of our modern civilisation gives us as many sources of fashion as there are centres of life. The demands arising from these sway modern trade. The psychologic bases of fashion have not been hitherto properly calculated in relation to trade questions; but I do not attempt now to discuss this question. I wish to consider if slavery to fashion is necessary. We cannot eradicate human instincts, but we may guide and elevate them. We have already tried, and will try again, to point out where the errors in fashion lie; to show a better way to a nobler end, through greater intellectual action, greater independence of spirit, greater depth of knowledge, greater keenness of conscience, to distinguish the true from the false, the beautiful from the ugly, the good from the evil.

THE LANGUAGE OF CLOTHING.

Dress can be considered as a language. It expresses not only the date and nationality, the sex and position of the wearer, but much of her past education, future intention, and present feeling. The white robes at confirmations and weddings; the blackness and darkness of funereal mourning is a part of this language. The dress suitable to the young girl, the matron, the industrious, the rich has each its own meaning. The French diplomatist Talleyrand said: "Words were given to hide thoughts;" so with clothes. They may hide the truth, they may express an intentional falsehood in the wearer's mind, or an unintentional falsehood based on ignorance or wilful inattention to facts.

NEED OF A RATIONAL DRESS.

In the utilities of dress we should not only consider the bare preservation of life, but of life in its fullest possibilities of physical perfection; we should consider modesty not only in its fundamental form, but in its dominating influence in ennobling and purifying the imagination; we should apply our notions of art not only to mere "decoration," but harmonious combination. In short, we should apply reason to fashion, so as to evolve a rational dress. I am not going at present to suggest or discuss the irrationalities of men's clothes. I believe there are some; but it would be like trying to cast out the mote from our brothers' eyes, while there is a beam in our own. I am a woman, and I only work for women. The true "advance of woman" means the advance of her reason; and the application of reason to her surroundings is the first sign of her advance. Does reason guide any of the interminable changes and varieties of the present day? Does fashion consider hygiene, physical or mental development, utility or art principles as part of her sphere? We deny that she does. It is only by accident that fashion is ever reasonable or artistic. But she may become both. A society has been founded for some years called "The Rational Dress Society," whose members differ on almost every point except the necessity of applying reason to fashion. We do not wish to eliminate beauty or decoration. We only fight against the unhealthy, the immoral, the ugly. Fashion blinds the eyes of its votaries; we wish by reason to open them.

UTILITY IN DRESS.

We have only to ask ourselves, Do we consider truly the question of utility in dress? Utility is the adaptation of means to an end. If either our means or our ends be wrong, we are equally at fault. Do we combine art with utility? I think we must all allow we err in both considerations.

FAULTS IN FEMININE ATTIRE.

The present faults in connexion with women's clothes we may divide into two classes. 1. The temporarily ridiculous, or disadvantageous. 2. The permanently injurious. Among the first we may class all modern forms of crinoline and dress improvers, tied back skirts, tied down arms and sleeves, over long dresses, over heavy trimmings, and any absurd fashion that impedes the action, freedom, or development of women, or outrages art. The most of the evils of this class pass with the change of fashion, and yet not always. There were many victims burnt through light dresses on extended crinolines; there have been many killed or injured through long trains. The aim of dressmakers, or whoever rules the fashions, seems to be to make women incapable of free motion or prompt action. Except on perfectly smooth clean ground, a woman cannot use her feet except by the aid of her hands. If she goes upstairs or up a hill she must lift her dress to prevent tripping; if she comes down she must lift her dress to prevent it catching behind, or soiling or tearing or wearing. If she crosses a muddy roadway she has to take it up all round, if her various other draperies will allow it. The consequence is that prompt physical action, in case of an emergency, is almost impossible to a woman; and, by disuse her powers become impaired. Another consequence of long dresses is uncleanliness and the risk of receiving infection of various kinds from street dust swept up by trailing robes. I am not now about to amuse you with an account of various accidents possible through the slavery to fashion, but only to point out the fact that many of these need never be if reason were applied to dress.

THE MISERIES OF FULL DRESS.

Of the second class, the permanently injurious, I may mention—first, the inequalities and disproportions of clothing. How many a girl goes out through the day in tweeds and furs, and shivers at night, through a long drive, in keen frost or in draughty passages, in some of the various miseries of full dress? How many colds, consumptions, and other diseases may be traced to these inconsistencies? But, as many miraculously escape, I shall not say more on this point.

HIGH HEELS.

Second, I may speak of what I may call a falsification of truth in dress; the increasing the stature by the use of high heels. I think very few women realise the terrible injury to their health they cause by using high heels, and this, therefore, I must call an unintentional falsehood based on ignorance. For high heels entirely alter the natural pose of the body, strain important internal organs, jar the delicate spinal cord, and exhaust the brain itself. It is a very different motion from walking on tiptoe, a natural expression of light spirits; but there is then no tap-tap from the heel right to the brain, repeatedly as each step is taken. No woman who wears high heels has the full use of her life, nor of her brain possibilities. When combined with tight shoes, as they generally are, her feet swell, exercise becomes unpleasant and painful, she reclines on a sofa, becomes delicate, lames herself, and establishes in civilised Europe an imitation of the Chinese feminine foot. I am not now going to narrate the terrible accidents that from time to time occur through the use of high heels. Some such must arise to the minds of every one. The only place in which high heels are really valuable is when we are walking up hill. Indeed, I have had some thoughts of taking out a patent for movable heels, to be screwed on when ascending mountains. But the woman who wears high heels is perpetually walking down hill; and one must remember the uncomfortable strain of a long-continued descent well enough to understand the effect of this injurious habit.

TIGHT STAYS.

But the third class of faults one may call an artificial diminution of truth, a falsehood, voluntary, and most injurious. The habit of wearing over tight gloves, garters, and boots is bad enough, and works much harm and helplessness; but the habit of wearing tight stays is an evil of national importance. If in a reasonable age we heard of a Government punishing malefactors by tight lacing, we would cry shame on it for cruelty, and demand the cessation of this horrible punishment. But think of the millions of women who daily inflict this torture upon themselves for the foolish desire of seeming an inch or two smaller than their natural size. Nature revenges herself for this falsehood. I am no learned physiologist, but in general phrases I may say that none of the compressed organs can act healthily and freely, a perpetual hunger-belt preventing either the reception or assimilation of natural and substantial meals, produces low-toned and ill-nourished bodies and brains, and a whimsical appetite, blotched complexions, abnormal depositions of fat. The tightened heart cannot have full play for the propulsion of the vital fluid, and has its palpitations, pantings, and spasms during its impeded action; the compressed lungs and air-cavities are unable to inhale the necessary quantity of air for the purification of the small supplies of poor blood; and the spine, which should be the support of the body, being disused, becomes weak and a source of suffering. When women, then, try to alter nature by such rude protests as tight stays, they break high laws, not only of truth but of hygiene. The breaking of these laws tends to manslaughter or suicide, and certainly prevents the natural development of body and of mind. The constitution that might have been strong for good is rendered feeble and dependent for help upon others. The thousand nameless weaknesses and languors that are supposed to be peculiar to our sex, are often only found in the tight-lacing portion of our sex. Last year, when this subject was touched upon in the Physiological and the Anthropological Sections, I mentioned that the average size of the female waist had decreased by two inches during the last 25 years. This may have been by the force of fashion during that period inducing women to compress their figures and risk these evils; or it may have been through their having inherited a lowered vitality from mothers who had laced tightly in the past. The question is worthy of consideration whether women, from any motive, are justified in following fashion to an extent that not only injures their own health, but tends to lower the physique of a whole nation.

THE UGLY SMALL WAIST.

There is no compensation for this destruction of the physical ideal of woman. The art-ideal is at the same time destroyed. Tight lacing prevents the natural development of the most beautiful outlines in animated nature, and substitutes for it an inartistic absurdity fashioned after the model of wooden Dutch dolls, out of all proportion, and devoid of real grace, like a Noah's ark figure, as Lady Harberton humorously calls it. Our eyes are blinded by custom, if we think a disproportionately small waist a pretty thing. Last year, in the Anthropological Section, I remember General Pitt-Rivers saying that he used to admire a woman with a small waist; but, after hearing what the doctors said, he declared he would never admire a small-waisted woman again. I merely give this as an illustration of how our eyes are blinded by custom to the truth. (Applause.) It is only advantageous to the dressmaker (the doll's or the woman's), as thereby her material can be hung on the figure with least trouble to herself. We must attempt to apply reason not only to the wearers, but to the makers of dress, and to the formers of fashion. True art ideas are built upon the laws of proportion, and upon the perfection of natural healthy development. Any standards of taste recognised by the civilised world are based upon the old statues of Greece, fashioned at a time when unhealthy and decrepit children were "put away;" when there were no hospitals; and when exercise was a necessary part of education. But the statue of the Grecian Venus was 5 feet 2½ inches in height, and the proportion of the size of waist to that stature is 26 inches. What modern Venus would not be horrified to appear in such natural proportions as these?

ITS IMMORALITY.

As a departure from truth, as a tendency towards much evil, many who now wear tight corsets should realise it as a moral wrong, as well as a physical and artistic wrong. All preventible diminution of vitality is a moral wrong. Instead of helping on the great cause of humanity by cheerful healthiness, they hinder it, by exacting help instead of giving it, by creating invalids to be tended. But few without careful consideration will realise that it is also an intellectual wrong. Mortals are partly spiritual and partly animal, but the development of the spiritual and intellectual greatly depends on the animal part of us. If, then, we starve, injure, or otherwise maltreat the physical part, the spiritual can never rise to its highest possibilities. I have heard a medical man, one much interested in the cause of women, Dr. Geo. Hoggan, gravely state, "There is no inferiority in woman except what comes through the bad education of her bad system of clothing." Whether this is so or not, I do not now dispute. But I do assert that women are inferior to what they might be through their errors in dress. We want the whole intellectual and moral force of women to help to regenerate the world. We cannot afford to fritter it away through evil habits. We want to look gravely and earnestly at a question hitherto only considered frivolous.

THE GREAT DESIDERATUM.

We want all women, fathers, husbands, brothers of women, to help towards elevating the perfection of physical development, creating a true standard of art-ideal, raising the conception of moral conscience, individual and national, enlarging the capability of woman's intellectual powers, and increasing a nation's well-being by considering what forms of clothing are best fitted to develop the feminine frame, naturally, healthily, perfectly. It is only through combination there is force. It is only through combined action and thought that we can ever hope to dominate through reason fashion that now dominates us; and, through raising fashion, raise those weaker than ourselves to judge in matters of right and wrong.

I have spoken on this subject in several drawing rooms in London, in the Women's Co-operative Guild of Bermondsey in connexion with the South London Women's University settlement; and in the International Congress of Women held in Paris on and after July 12th of this year. Many who have thought the question frivolous, after discussion saw its importance. To my mind it is of an importance equalled only in momentous solemnity by the great question of national intemperance. (Loud and continued applause.)

REMARKS AND DISCUSSION.

The CHAIRMAN said: My first duty is a most pleasing one. It is, as I gather from the applause with which you have showed your appreciation of Mrs. Stopes' address, through you to convey to Mrs. Stopes our grateful acknowledgment and thanks for her most able, most interesting, carefully prepared, and also, if I may be permitted to say, most beautifully enunciated address, respecting this most important question. I propose a very hearty vote of thanks to Mrs. Stopes for her able, most interesting, and valuable address. (Loud applause.)

The MAYOR of NEWCASTLE said: I have very great pleasure in rising to second the vote of thanks which has just been moved to Mrs. Stopes for her interesting, instructive, and valuable address. Unquestionably on all matters of this kind we are slaves to fashion. Little has been said to-day on the male dress, but I believe we are just as much the slaves of fashion as our sisters are. (Laughter, and "Hear, hear.") Unquestionably a surtout coat helps to make up a man; but if I consult my own ease—and I now speak from experience—my own health and comfort, I would always loll about in a loose woollen shooting jacket. (Laughter and applause.) With regard to ladies' dress, I cannot speak from experience—(laughter and applause)—but I think the question has been fairly divided into that of utility and art. Mrs. Stopes has referred to the dresses prevailing in more ancient and classical times. I am speaking of the Greek and Roman periods. History does not bring us to any information of corsets. Pictures represent to us the ladies marching about in loose, flowing robes. The question, I say, has been divided into one of utility and art. Upon the question of utility, our friend, Dr. Philipson, ought really to be able to give us some information. I confess to you I cannot. If corsets, for instance, be an actual necessity for female support, then any argument to the contrary immediately falls to the ground; but I must say I am very incredulous upon that point, for I cannot conceive that a Divine Being would launch a female race into existence demanding such unnatural props as they at present use. (Loud applause.) That, of course, touches the question of health. If the use of these unnatural garments impede the internal organs, their natural health, and their voluntary action, that is a question for the ladies themselves. But when we go into the region of art—that is for me and my sex—for undoubtedly in the region of art you pay attention to our views—(hear, hear)—and to our tastes. I have yet to learn that there is any beauty in compression or in straight lines. I have always been taught to believe that beauty in nature as well as in art lay in curves and undulations—(applause)—and therefore, if you are putting this strait lacing before our sex as a matter of art and as an attraction, I believe the theory is about exploded. (Applause.) Let me say, in conclusion, that the time has now arrived for the discussion of the subject, and that I hope that a more rational dress is in store for our ladies. (Loud applause.)

The resolution was then carried by acclamation.

The **Chairman**, after inviting discussion, said: You remember that Mrs. Stopes thought it right to give an introduction respecting the history of dress, and, after giving us a very interesting historical account as to dress, Mrs. Stopes very properly divided her subject into two great divisions, which the Mayor has most properly referred to in the important remarks with which he has favoured us. I do not wish to entrench upon the time of the speakers in discussing this important question, but I should wish to give expression to my own feelings on the subject of dress from a professional point of view. This is comprised of three main points. The first is as to the protection of the body—which is to afford such warmth to the body as to preserve the body in health, because warmth to the surface of the body generally is so important—in fact, it is equally as important almost as the fresh and pure air for the regeneration of the blood, because we have in remembrance that the skin of the external surface of the body is equally as important as the internal surface of the body, the mucous track, also the circulatory and respiratory organs. Therefore I think this physiological effect of dress is the basis we should always have in mind—the preservation of the warmth of the surface. The next point Mrs. Stopes has referred to most emphatically, and directed the attention of ladies to, is as to compression. Compression upon any surface of the body or extremities must be fruitful of ill, and, as Mrs. Stopes descanted upon this part in most beautiful, appropriate, and most convincing language, I feel that this will be accepted by all present. Professionally, I can say that I have seen great harm upon the internal viscera by these pressing influences — health degenerated, health interfered with, and the comfort of the individual diminished. The third point to which Mrs. Stopes directed attention was the æsthetic, the effect of art, and the Mayor again most properly commented upon this—that dress should be becoming—if I may be permitted to use such a term—to the individual, and should give satisfaction to all. These were the points that seemed to me to be the most important in this learned, this instructive, and telling address. You will excuse me for not occupying the time of this large assembly longer, because I do not wish to interfere in any way with those who have come prepared, ladies and gentlemen, to take part in this most important discussion.

The discussion was opened by

Miss **Ray**, who, having a great many nephews and nieces, could bear testimony to the misery which infants were put to by a multiplicity of dress at the beginning of their lives. (Applause.) Had she had children to deal with, she would have put them in a flannel bag for the first three months. She would suggest to mothers the advisability of leaving off two-thirds of the small articles of infants' dress. For instance, the pushing of five small fingers through an armful of wool, and five little toes into small woollen socks, was a state of things which, in the nineteenth century, ought to be brought to an end. (Applause.)

Dr. **Garson** (Recorder of the Anthropological Section of the British Association) said he was one of those who admired the natural shape of the body. He was one of those who saw beauty in a shoe formed to the outline of the foot, and the proportions of the body in their natural outline. The basis of the whole subject brought before them that morning must be the effects that dress produced on the different structures which composed the human body. The effect of high heels was to do away with the two beautiful arches of the foot. They strained the ligaments, and this interfered very materially with the natural formation of the foot. The effect on the legs was to shorten the muscles. Then as to corsets he would like to say a few words. Pressure on the skin tended to diminish the size of the numerous small blood vessels, and consequently by tight lacing the quantity of blood which went to the skin was reduced in quantity. The blood conveyed nourishment to all the structures, and consequently by tight-lacing they had a diminution of the nutrient fluids going to the skin. If the stress on the sides was very marked on one set of muscles, their functions were interfered with. Muscles increased in size and strength as they were used; but, if they were compressed, they diminished instead of increased in size. Anyone who practised tight lacing from an early period altered the general curve of the ribs, which instead of arching round became compressed and straightened. It was the lower part of the ribs which was compressed. By tight lacing the intestines were pushed downward and the bloodvessels of the abdomen were compressed. The stomach was also compressed, and thus the full complement of blood requisite for the proper digestion of food was interfered with.

Miss **Findlay** said that, while agreeing in the main with Mrs. Stopes, there were one or two points on which she would like to speak. She would like to ask if the question was between corsets and no corsets, or between tight corsets and loose corsets, because she thought this made a very great difference. Of course, anyone who knew anything of her own body was quite aware of the injury and discomfort that were caused by tight lacing. But from her own experience, she considered that to have no support at all was uncomfortable. The Mayor had told them that he admired curves and undulations. She supposed they all did. But in the figure of a woman who wore no corsets the lines were straight, both perpendicularly and horizontally. (Laughter and applause.) It was extremely difficult in our climate and with our occupations to have a dress which would really be hygienic and artistic and in every way suitable. (Applause.)

The Rev. T. G. **Headley** said that at a time when there were no railways, and the village or town had but little knowledge of how people dressed outside of their own immediate neighbourhood, and still less how people dressed in other countries it would be a matter of great interest to hear how people dressed in other cities and countries; but now that we could traverse the whole world by means of railways, it can be easily known how other people dress, and, therefore, if there was a dress superior to our own we should have expected to see a model of it; but, as no model was shown to us, we must assume the dresses of the ladies in the hall exhibited the best models that could be seen up to the present date. And when we bore in mind that in ancient times it was a frequent custom to destroy infants that did not promise to be of good form, we could well understand how much less important dress would be then than it was now; for when the human form was so perfect that it was like to either a Venus or an Apollo, we could then understand that the human form would need no artificial aid of adornment, as their beauty unadorned would be adorned the most. And when the human form deteriorated, then both men and women sought to supply or hide their deficiencies by the artificial means of dress, and those artificial means must be diverse, owing to the different deficiencies of men and women; so that it was impossible to fix one standard or model for all, which was practically admitted by no model being submitted for approval.

Miss LYDIA BECKER, of London, said she was an out-and-out defender of the corset as absolutely necessary, alike for the health, comfort, and appearance of a woman, under the present conditions. And she held that those who counselled women to abandon corsets were speaking—she did not say without knowledge, but certainly she thought that if their theories obtained very considerable injury would be done. The defenders of the corset need hardly defend it, because they had almost universal purchase on their side, and, therefore, it was more right that they should hear the views of those who attacked them than of those who simply went on as they had been accustomed to do. There was a great difference between the abuse and use of corsets, between tight lacing and that moderate amount of compression of the waist which they many of them found so desirable. (Applause.) A "wasp" waist was, to her mind, distinctly ugly. What they wanted in a corset was graceful undulations and beautiful curves, to show the body in its natural beautiful curvatures. But the wasp waist destroyed these curves, and produced what was physiological deformity, and was very ungraceful to the trained eye. Even the extremest modes of tight-lacing, even the extremest wasp waist, were not so injurious as doctors would have them believe. If they were, she really did not see how the ladies of the present day could survive, because unquestionably that fashion was in the ascendant. What was really injurious was not the corsets, but the bands round the waist, from which depended long and heavy and cumbrous skirts. (Applause.) If fashion would only allow the length of the skirt to be abridged a little, that would be a very great relief. (Applause.)

Dr. WILBERFORCE SMITH exhibited a diagram showing the original shape of the waist, and its shape when constricted by the corset. Whilst he agreed with the lady who had spoken of the difference between tight lacing and of the ordinary wearing of stays, still he was bound to say that, from large experience, the mere ordinary wearing of stays produced, only in less degree, the main evils which were produced by actual tight lacing. It was possible to detect when a woman was constricted. He wished men to take note of this, because male opinion had a great deal to do with the matter. When a man got accustomed to detect at once when a woman was constricted by the corsets, that which he might previously have admired, he could not possibly admire, because he was conscious of how much evil there was underneath, and at what a terrible sacrifice the constriction had been produced. He had got into the strange feeling, when he looked at a man and a woman from behind, to admire the man rather than the woman, because he had come to look at the play of the muscles of the back, which was apparent in the man, while the woman's back was quite rigid. Such diseases as gallstone and floating kidney, due to compression, were far more frequent in women than in men, the latter being confined to women exclusively. Last year, he was able to give several records showing the greatly increased superiority in breathing power of women who wore no corsets, compared with those who did wear corsets. (Applause.)

Mrs. BARSTOWE (London) spoke in favour of corsets, and said if they were entirely dispensed with, the whole dress would have to be reformed.

Dr. WILSON (Alnwick) would not on any account advocate the abolition of corsets. He was not an advocate of tight lacing, but an advocate of the adoption of a happy medium in regard to the wearing of corsets.

Dr. EMBLETON (Newcastle) said there were two kinds of corsets—a good one and a bad one, the hygienic and the non-hygienic; one which compressed too much, and one which did not compress more than was absolutely necessary or beneficial. The bad corset had the effect of compressing the skin in the first instance; it interfered with the circulation through the skin, compressed the muscles under the skin, and rendered them less perfect in their action. Further, the bones of the chest were altered in shape, the internal organs were compressed—those over the chest—and the liver was pushed upwards or downwards, or both. He had seen in a *post mortem* examination the liver approaching the shape of the hour-glass, as the waists of some ladies, and particularly young ladies, were at the present time. The stomach was interfered with, it was compressed, and then the shape was altered. The spleen was compressed and altered in its function. The upper digestive organs were, generally speaking, pushed upwards, so as to press the lungs and diminish the respiratory powers of those organs. The effects on the organs below the waist were equally injurious. At the present time young ladies were in a state of madness as to the size of their waists, and they vied with each other as to which could get the smallest possible waist. He also referred to a leather belt for the waist which had recently come into fashion. This belt was used to tighten and compress the waist. All these belts should be pulled off and burned. He had known people die from tight-lacing, and he urged ladies to abstain from that most ridiculous and disfiguring fashion—a small waist. They did not know how injurious it was, or they never would follow it.

Mrs. STOPES, in replying to the discussion, said she quite agreed with all the Mayor said, and probably would agree with all that the doctors said, if she understood them. They had enlightened her in very many points that she did not know before. All the doctors apparently were on the side of her proposition that tight stays were most injurious. She did not think there had been any difference of opinion in the medical section. She could not answer them. The questions she would like to answer were those of some of the ladies. One lady asked if the discussion was a discussion between tight or loose stays and corsets, or between corsets or no corsets. The question was nothing of the kind, as far as regarded herself. The point that she was bringing before them was the application of reason to the clothes altogether from the foundation. The most injurious habit of the present day was the habit of tight lacing, and consequently the discussion had turned almost entirely, and very appropriately, in that direction. She was glad to hear that Miss Becker had solved the question. (Laughter.) She herself had not solved the question by any means at all. What she wanted to settle was how to dress herself as well as she could, and to get as much out of her dress as she possibly could, and give other people as little trouble as she could. She wanted to be able to dress her children in the best possible way, and she would like exceedingly to have solved all the large number of questions that came before the reasoning mind when put before the question of dress. She had visited two of the court dressmakers in London during the past year, and she was very thankful to hear them say, "Do you know, madam, that tight-lacing is beginning to go out?" (Applause.) There was not the slightest necessity for the waist-bands; only with these it was easier for dressmakers to dress them than without them. Ten years ago, there was a fashion, called the Princess fashion, in which the dress came from the shoulder. She did not consider the question of men's opinion in this respect, because men would always admire the fashionable, whatever fashion was. This was because in men, as in women, the eyes became blinded by fashion. What they really wanted was to get behind fashion and to move fashion in the right direction. This could only be done by the application of numbers, as well as by the application of reason; and the whole meaning of her paper was to suggest that all ought to think on the subject, and to try and work out their thoughts. (Applause.)

A hearty vote of thanks passed to the chairman for presiding brought the proceedings to a close.

EXCURSION DAY.

Thursday, the day after the closing meeting, was devoted to excursions to various interesting places in the Northern Counties. The excursions were twelve in number, the following being a complete list :—

Warkworth and Alnwick.
Berwick (Norham Castle, Ford Castle, Flodden Field, and Burnmouth).
Bamburgh.
Howick (Dunstanburgh Castle and Rock).
Holy Island.
Chillingham.
Rothbury and Cragside.
Roman Wall.
Lanercost Priory and Naworth Castle.
Middleton-in-Teesdale (lead mines, High Force, and Cauldron Snout).
Barnard Castle, Rokeby and Raby.
Middlesbrough.

WARKWORTH AND ALNWICK.

A large party of the members assembled for the trip to Warkworth and Alnwick. At Warkworth they were met and conducted to the ancient parish church of St. Lawrence and to the Castle and Hermitage, which were described by Canon Dixon. The Castle was the scene of much of Shakespeare's Henry the Fourth, and the stronghold in which the great dramatist says the Earl of Northumberland lay "crafty sick." It had become a favourite residence of the Percies in the 15th century, and contains banqueting hall, state chamber, a buttery with ready access to the adjacent kitchens, a chapel, an oratory, private apartments, guard chamber, and other places. Portions are of the 12th and 13th century ; the keep is of the 15th. The hermitage was cut and sculptured in the 15th century in the solid freestone rock. The chapel, which is entered through a porch, is 20 feet long by 7 high, set out into three equal bays by pillars, ribs, and vaulting.

At Alnwick, the principal object of interest was, of course, the castle. After inspecting the noble Edwardian barbican protecting the entrance, and passing the various towers within, notably the Prudhoe tower, the party were conducted through the principal apartments. The lofty and spacious kitchens were no less admired than the magnificent marble staircase, drawing rooms, dining rooms, and library. The saloon, with its art treasures and pictures, formed a strong attraction for the visitors, and the same may be said of the chapel, the state bed rooms, the duchess's boudoir, and other private apartments. Alnwick Abbey, the ancient Church of Sts. Michael and Mary, and other buildings of note were also visited.

BERWICK.

The Berwick excursionists were received at the Border town by the Mayor and Reception Committee, and conducted around the walls. At the Museum King James's charter of the town was shown. After viewing the bridges, fortifications, and buildings, the party in the afternoon drove to Norham Castle, which was founded by Flambard, Bishop of Durham, in 1121, and which formed a prominent feature in Border warfare for centuries. In 1497, the famed monster gun Mons Meg was brought from Edinburgh to assist in the reduction of the castle by the Scots. It has been in ruins since Elizabeth's time. Flodden Field was also visited, the party driving to Marmion's Hill, where the thick of the fight raged. Ford Castle, where James IV. slept on the night before Flodden, was next driven to, and then the party went to Burnmouth, a picturesque Scotch fishing village with interesting geological features.

BAMBURGH.

Bamburgh, Howick, Dunstanburgh and Rock were fairly patronised by members. Detraining at Belford, the party walked to Chester Hill Camp, and were afterwards driven to Spindlestone Crag, where they inspected the camp on the summit, and also enjoyed the fine views of Holy Island, the Cheviots, and other landmarks. Continuing the drive to Bamburgh, noting by the way the burial place of Grace Darling, Bamburgh Castle is reached. It ranks sixth or seventh among the castles of Northumberland, yielding only to Dunstanburgh in the grandeur of its situation and its extent. Its prehistoric associations stand absolutely unapproached by any other Border stronghold. Known to the Celts by the name of Dinguarvy, it first appears in history in connexion with the rise of the kingdom of Bernicia. Twice was the rock of Bamburgh besieged in vain by Penda. Bamburgh maintained its impregnable character throughout the civil turmoils of the eighth century, but fell before the arms of Athelstan in 924, when King Alfred was forced to flee from this his Royal city. Nominally the kingdom of Northumberland dragged on its existence for another quarter of a century, and then Bamburgh became the residence of a line of powerful earls. The castle since then has played a prominent part in English history. It has been visited by kings, invested, bombarded, and experienced other vicissitudes. In 1720 Lord Crewe left the greater part of the property to trustees for charitable purposes. One of the trustees commenced, at his own expense, the restoration of the castle, and established in it the schools, surgery, library, and appliances for the warning and rescue of crews in distress. The administration of these princely charities has now been considerably modified ; the girls educated in the castle are charged a small sum for their board, and the keep is allowed to be let.

Howick Hall, the seat of Earl Grey, built in 1782, on the site of an old border tower, was next visited. It was the home of the distinguished statesman whose name is so inseparably connected with the passing of the Reform Bill in 1832, and contains rare pictures by celebrated artists.

Dunstanborough Castle was the next object of interest. It dates from the year 1313, and was built by Thomas, Earl of Lancaster. During the wars of the Roses, Dunstanborough Castle was taken and retaken no less than five times, and as artillery was used in these sieges, it was much shattered.

HOLY ISLAND.

Excursions to Holy Island are always popular, and the present formed no exception to the rule, especially as it combined a visit to Chillingham. Train was taken to Beal, from which it is three-and-a-half miles to Holy Island, mainly over sands which remain uncovered for six hours and a half each tide. The history of the island began with the year 635, when St. Aidan, an Irish monk from Iona, who had accepted the invitation of King Oswald to teach the new faith to the Northumbrians, made it the seat of his Episcopacy. His success was such that 15,000 persons are said to have been baptised by him in seven days. Cuthbert, the sixth bishop, began his pastoral oversight of the see in 685. When the monks fled from the Danes at Lindisfarne, the church and monastery were reduced to ruins, in which state they remained for over 200 years. In 1093 the foundations of the present priory and church were laid, and they were opened about 1120. As late as 1750-1780 the centre tower was standing.

Chillingham, the home of the wild cattle, was afterwards reached. The castle was completed by 1348. In the reign of Henry III., it formed part of the vast possessions of the then Lord of Alnwick. The cattle are as wild now as they were in the 13th century.

ROTHBURY AND CRAGSIDE.

A large party of excursionists left Newcastle by train to Rothbury, one of the most charming holiday resorts in the county of Northumberland. Although there is much that is instructive and interesting in Rothbury, the great attraction is undoubtedly the seat of Lord Armstrong at Cragside, which occupies an elevated site on a plateau, midway up the face of a boulder-covered hill of sandstone rock. Apart from the glorious beauty of its mountain scenery, Cragside contains within its walls great attractions in the many rare and costly treasures of art and literature. Lord Armstrong became the owner of that bleak range of hills in 1863, and, after erecting his country house upon it, called it "Cragside," to which tower after tower and wing after wing have since been added.

Brinkburn Priory, an interesting relic of the monastic age, stands in a most romantic and secluded situation on the north bank of the river Coquet.

THE ROMAN WALL.

A trip to the Roman Wall is always well patronised, and on reaching Bardon Mill the conductors, Dr. Bruce and Mr. Blair, found a large party ready to avail themselves of their services. The Roman Wall consists of two lines of fortification, a stone wall and an earthen wall or vallum. The stone wall runs from Wallsend to Bowness, on the Solway, a distance of 74 miles. It is from 7 to 8 feet thick, and in Camden's day was standing in one place 15 feet high ; what its original height was is not known. At distances averaging four miles along its course are stationary camps for the accommodation of the soldiery who formed its garrison. The largest of these stations, Amboglanna, Birdoswald, occupies an area of five acres and a half. On the wall there were also what are called mile castles, measuring 60 feet in each direction, and sentry boxes 12 feet square.

LANERCOST PRIORY AND NAWORTH CASTLE.

By permission of the Earl of Carlisle, a party of excursionists were allowed to visit Lanercost Priory and Naworth Castle. Lanercost was founded in 1169 by Robert De Vallibus, second baron of Gilsland, and consecrated by Bishop Christian, of Candida Casa. It is recorded that Edward I. and his queen stayed there in the year 1280. Nothing is known of the priory from 1409 to 1536. It fell with the smaller religious houses, and its last prior, Robert Robinson, became rector of Aikton in Cumberland. In 1559, Thomas Dacre, to whom the place was granted by Henry VIII., converted the western range of the priory buildings into a dwelling-house. The last Dacre of Lanercost died without male issue, and the site of the priory and demesne lands reverted to the Crown, and were some time afterwards purchased by the Earl of Carlisle, to whom they now belong. The greater portion of the buildings now remaining are of first pointed architecture of the 13th century.

Naworth Castle stands on a triangular tongue of land, formed by the castle beck on the north, and a little rivulet on the south, which unite and flow into the Irthing. To Lord William Howard, whose date is handed down by a leaden spout-head on the entrance-front with his initials and 1602 upon it, must be attributed the domestic character the castle bears.

MIDDLETON-IN-TEESDALE AND BARNARD CASTLE.

The visitors to Barnard Castle found themselves in a market town on the banks of the Tees. The place derived its name from Bernard Baliol, whose father Guy came over with the Conqueror, and received the Barony of Gainford and other property in the north as a reward for his services. The chief object of interest in the town is the old castle, which was built 1112-1132 by Bernard Baliol on land given to his father Guy, in 1098, by William Rufus. In 1569, the Castle underwent its famous siege when Sir George Bowes held it for eleven days against the Earls of Northumberland and Westmoreland, in the "Rising of the North." In 1629, the Castle was sold to Sir Henry Vane from whom it descended to the Duke of Cleveland. Some of the party also visited the interesting spots to be found at Middleton, including the High Force and Cauldron Snout.

MIDDLESBROUGH.

Middlesbrough proved to be an attractive excursion. Famous for its iron and steel industries it may be said that more than one-third of the whole of the iron produced in the United Kingdom is made in the Cleveland district of which Middlesbrough is the capital. Accompanied by competent *cicerones*, the excursionists were enlightened upon the rapid rise and marvellous development of this modern town. They were told of the shipments of iron and steel, shown the shipbuilding yards, salt mines, and chemical works, the Tees, the South Gare breakwater, the works of Bell Brothers, Bolckow, Vaughan, and Co., and other manufacturers, from which they carried away with them a store of information almost bewildering in its extent for the short period during which Middlesbrough has existed.

Thus ended the 59th annual meeting of the British Association for the Advancement of Science, and the third meeting of the Association in the city of Newcastle-on-Tyne.

INDEX.

PAGE

British Association, The.—Its Origin and Its Work.. 3
British Association.—Former Meetings in Newcastle 5
Distinguished Visitors, List of 9
The President: Biographical Sketch of 11
The Sections and their Presidents 13
First Day's Proceedings (Wednesday)—
Meeting of General Committee 7
Presidential Address 27
Second day's proceedings (Thursday) 38
Papers read in Section A 38

1. President's Address.
2. Report of the Committee on Tidal Observations in Canada.
3. Report of the Committee on the Practical Work of Tidal Observation.
4. Report of the Committee on the Harmonic Analysis of Tidal Observation.
5. Dr. H. Muirhead.—On the Heliocentric Longitudes of Cometic Perihelia.
6. Professor A. W. Rücker, F.R.S.—On Cometic Nebulæ.
7. Professor Piazzi Smyth.—Re-examination of the Spectra of 23 Gas-vacuum End-on Tubes after 6 to 10 years of existence and use.
8. Lord Rayleigh, Sec. R.S.—On the Tones of Bells.
9. Professor J. Milne.—On Seismological Work in Japan.
10. Professor J. Milne.—On the Vibrations of Railway Trains, with Exhibition of a New Instrument for Recording these Vibrations.

Papers read in Section B 42

1. President's Address.
2. Report of the Committee on the Influence of Silicon on the Properties of Steel.
3. Report of the Committee on the best method of establishing an International Standard for the Analysis of Iron and Steel.
4. Professor Liveing.—On Eikonogen, a new Photographic Developer.
5. J. W. Hogg.—The Volatilisation of Lead Oxide and its action on Glass, at Low Temperature.
6. C. T. Heycock, M.A., and F. H. Neville, M.A.—On the Molecular Weight of Metals: an application of Raoult's Method to Alloys.
7. Dr. J. B. Readman.—The Manufacture of Prussiate of Potash.

Papers read in Section C 45

1. The President's Address.
2. Professor J. Milne.—Report on the Earthquake and Volcanic Phenomena of Japan.
3. Professor G. Michie Smith.—The Bandaisan Eruption, Japan, July, 1888.
4. Dr. E. Naumann.—Terrestrial Magnetism as modified by the Structure of the Earth's Crust; and Proposals concerning a Magnetic Survey of the Globe.
5. T. P. Barkas.—Notes on numerous newly discovered fossil footprints on the Lower Carboniferous Sandstone of Northumberland, near Otterburn.
6. T. Mellard Reade.—The Physiography of the Lower Trias.

Papers read in Section D 51

1. The President's Address.
2. Report of the Committee on Natural History of the Friendly Islands.
3. Report of the Committee on the Zoology and Botany of the West India Islands.
4. Report of the Committee on the Development of the Oviduct of certain Fresh Water Teleostei.
5. Report of the Committee on the Disappearance of Native Plants.
6. Report of the Committee on the Migration of Birds.
7. Report of the Committee on the Naples Zoological Station.
8. Report of the Committee on the Flora of China.

At 1 p.m. the Section subdivided into Zoological and Botanical Departments.

ZOOLOGICAL DEPARTMENT.

1. B. H. Thomson.—Notes on the Fauna of the Louisiade and d'Entrecasteau Islands.
2. Rev. Canon Tristram, F.R.S.—On the Peculiarities of the Avifauna of the Canary Islands.
3. Professor Newton, F.R.S.—On *Syrrhaptes paradoxus* as a native of Britain.
4. Professor Windle.—On the Morphology of the long flexors of the digits of the Mammalian Hand,
5. Professor Windle.—On certain Congenital Abnormalities in Fishes.
6. F. E. Beddard.—On the Cæca of a Tinamou.
7. F. E. Beddard.—Contributions to our Knowledge of the Fresh Water Annelids.
8. Professor McIntosh, F.R.S.—Note on the Tarpon *(Megalops thrissoides)*.
9. Professor McIntosh, F.R.S.—On the Larval and Post-larval stages of the Sole and other Food-Fishes.
10. Professor McIntosh, F.R.S.—Notes on new and rare Forms at the St. Andrew's Marine Laboratory.

BOTANICAL DEPARTMENT.

1. J. G. Baker.—The Occurrence of *Arenaria norvegica* in Yorkshire.
2. Professor F. O. Bower.—The Meristem of Ferns as a Study in Phylogeny.
3. Professor M. Hartog.—The Structure of the Nucleus in *Saprolegnia*.
4. H. Wager.—Observations on the structure of the Nuclei in *Peronospora parasitica*, and on their behaviour during the formation of the Oospore.
5. A. W. Bennett.—The Antherozooids of Cryptograms.
6. A. W. Bennett.—A Hybrid Desmid.

Papers read in Section E 56

1. President's Address.
2. Sir Robert Biddulph, G.C.M.B.—Cyprus.
3. Captain Thys.—The Congo Railway.
4. Dr. H. R. Mill.—Physical Basis of Commercial Geography.
5. Rev. R. P. Ashe.—Uganda.
6. His Excellency Governor Moloney.—The Yoruba Country, West Africa.

Papers read in Section F 59

1. The President's Address.
2. Professor C. F. Bastable.—The Incidence and Effects of Import and Export Duties.
3. Stephen Bourne.—Index-Numbers applied to the Statistics of Imports and Exports.

Papers read in Section G 65

1. The President's Address.
2. Professor A. B. W. Kennedy.—Experiments on the Transmission of Power by Compressed Air (Popp's System.)
3. A. C. Humphreys.—Water Gas.

Papers read in Section H 71

1. Francis Galton, F.R.S.—On the advisability of assigning Marks for Bodily Efficiency in the Examinations of Candidates for the Public Services.
2. Francis Galton, F.R.S.—On the Principles and Methods of assigning Marks for Bodily Efficiency.
3. President's Address. [Subject—Heredity.]
4. Dr. W. Wilberforce Smith.—The early failure of pairs of Grinding Teeth.
5. Dr. Ridolfo Livi.—On the Development of the Wisdom Teeth.

PAGE
6. W. K. Sibley, M.B.—Left-leggedness.
7. Professor D. J. Cunningham.—The occasional eighth true rib in Man, and its relation to Right-handedness.
8. Professor D. J. Cunningham.—The proportion of bone and cartilage in the lumbar section of the vertebral column in the Apes and in different races of Men.
9. Professor D. J. Cunningham.—Exhibition of the Model of the Head of a Man stated to be 106 years old, with the Brain exposed *in situ*.
10. Professor D. J. Cunningham.—Exhibition of the Model of the Head and Shoulders of a young Orang Utan, with the Brain exposed *in situ*.

Meeting of Delegates 76
Banquet at Jesmond Dene 77
Conversazione at the Museum 80
Third Day's Proceedings (Friday) 82
Papers read in Section A 82
1. Captain Abney, F.R.S.—Intensity of Light productive of Density of Deposit in a Photograph.
2. Lord Rayleigh, Sec. R.S.—On Pin-hole Photography.
3. Sir W. Thomson, F.R.S.—On Boscovich's Theory.
4. Professor O. J. Lodge, F.R.S., and R. T. Glazebrook, F.R.S.—On the determination of "*v*" by means of Electric Oscilations.
5. Professor A. W. Rücker, F.R.S.—On the Instruments used in the recent Magnetic Survey of France.
6. Report of the Committee on the Magnetisation of Iron.
7. Professor J. A. Ewing, F.R.S.—Magnetic Viscosity in Iron.

Papers read in Section B. 83
1. Report of the Committee for the purpose of inquiring into and reporting on the present Methods adopted for teaching Chemistry. (Followed by a Discussion.)
2. Professor P. P. Bedson, D.Sc.—On the Manufacture of Aluminium from Cryolite.
3. J. Pattinson and Dr. H. S. Pattinson—On Chilian Manganese Ore.
4. Professor Frank Clowes, D.Sc.—On Barium Sulphate Deposits from the Waters of Durham Coal Mines and in Nottingham Sandstone.
5. J. H. J. Dagger, F.I.C.—The Manufacture of the Alloys of Aluminium in the Electric Furnace.

Papers read in Section C 85
1. Dr. A. G. Geikie—On the origin and age of the Crystalline Schists of Norway.
2. J. E. Marr—Dynamic Metamorphism of Skiddaw Slates.
3. Dr. F. H. Hatch—On the Lower Silurian Felsites of the South-East of Ireland.
4. A. R. Hunt—The Age of the Granites of Dartmoor and the English Channel.
5. R. Swan—The Island of Paros, in the Cyclades, and its Marble Quarries.
6. Professor T. G. Bonney.—Preliminary note on the alleged occurrence of Fossils in the Crystalline Schists of the Lepontine Alps.
7. W. W. Watts.—To exhibit Specimens of Belemnites from Lukmanier.
8. Professor T. G. Bonney.—The Effects of Pressure on Crystalline Limestone.
9. J. J. H. Teall.—The Amygdaloids of the Tynemouth Dyke.
10. Dr. F. Nansen.—Greenland.

Papers read in Section D 87
1. Discussion on "Acquired Characters," opened by E. B. Poulton, F.R.S.—On the supposed transmission of acquired characters, and F. Galton, F.R.S.—Feasible Experiments on the possibility of transmitting acquired habits by means of inheritance.
2. Professor H. F. Osborn.—The Palæontological Evidence for the transmission of acquired characters.
3. Report of the Committee on the Improvement of the Deep Sea Tow-net.
4. G. C. Bourne.—On an Improved Form of Deep Sea Tow-net.
5. Report of the Committee on the Botanical Station at Peradeniya.
6. Sir John Lubbock, F.R.S.—On the Shape of the Oak Leaf.
7. Sir John Lubbock, F.R.S.—On the Leaves of the Guelder Rose.
8. Professor J. Cossar Ewart.—On the Modifications of Electric Organs in Elasmobranch Fishes.
9. Professor J. Cossar Ewart.—Observations on the Migration of Fishes.

Papers read in Section E 89
1. Colonel Mark S. Bell.—The Russo-Chinese Frontier Region.

PAGE
2. R. Gundry.—China.
3. Hon. G. Curzon, M.P.—The Central Asian Railway in relation to the Commercial Rivalry of England and Russia.
4. W. J. Flinders Petrie.—Wind Action in Egypt.
5. Capt. Hore.—Lake Tanganyika.
6. J. Batalha-Reis.—Recent Portuguese Explorations in Africa.
7. Captain Lugard.—Nyassaland.
8. J. Rankin.—The Mouths of the Zambesi.

Papers read in Section F 92
1. Rev. Dr. Cunningham.—The Comtist Criticism of Economic Science.
2. Professor Edw. Hull.—The State of our Coal Resources.
3. H. R. Fox Bourne.—Our West African Possessions: their commerce and civilising influences, their fiscal arrangements and true administrative policy.

Papers read in Section G 94
1. Beauchamp Tower.—Apparatus for providing a Steady Platform at Sea.
2. Professor J. Milne.—Vibration of Railway Trains.
3. H. M. Ashley.—Bottle Making Machinery.
4. J. A. London.—Paper from Fibrous Peat.
5. C. E. Carr.—Hydraulic Apparatus for Railway Signalling.

Papers read in Section H 96
1. Rev. J Wilson, M.A.—Hypothesis of a European Origin of Early Egyptian Art.
2. H. E. Governor Moloney.—African Airs and Musical Instruments.
3. Paul B. Du Chaillu.—The Vikings the Direct Ancestors of the English-Speaking People.
4. Canon Isaac Taylor, LL.D.—Further Researches as to the Origin of the Aryans.
5. Canon Isaac Taylor, LL.D.—The Ethnological Value of the Beech.
6. Hyde Clarke.—The Right of Property in Trees in Another's Land as an Origin of Right of Property.
7. Report of the Nomad Tribes of Asia Minor Committee.

Lecture by Mr. Roberts-Austen
"The Hardening and Tempering of Ste. " } 98
The Lectures of the Association 100
Fourth Day's Proceedings (Saturday) 103
Papers read in Section A 103
1. Report of the Committee on Bessel's Functions.
2. Dr. Meissel.—On some Formulæ connected with Bessel's Functions.
3. Professor J. D. Everett, F.R.S.—On the Relation between Brachistochrones and Ray-paths.
4. Professor Cayley, F.R.S.—On Curves in Space.
5. A. B. Basset, F.R.S.—On the Extension and Bending of Cylindrical Shells.
6. T. Woodcock.—Simplified Proofs (after Euler) of the Binomial Theorem.
7. Lord Rayleigh, Sec. R.S.—On the Extensibility of Liquid Films.
8. Professor J. A. Ewing, F.R.S.—Hysteresis in the Relation of Strain and Stress.
9. Dr. G. Johnstone Stoney, F.R.S.—On the Relation of the Ether to Space.
10. Professor H. Stroud.—On the E.M.F. produced by an abrupt Variation of Temperature at the Point of Contact two Portions of the same Metal.

Papers read in Section C 103
1. Professor C. Williamson.—Report on Coal Plants: On the present state of the Inquiry into the Microscopic Features of the Coal of the World, and into the Organisation of the Fossil Plants of the Coal Measures.
2. Professor T. Rupert Jones.—Report upon the Fossil Phyllopoda of the Palæozoic Rocks.
3. Dr. H. J. Johnston-Lavis.—Report on the Volcanic Phenomena of Vesuvius.
4. Professor E. Hull.—To exhibit specimens of supposed Coral structures from Culdaff in Donegal, and to invite opinions thereon.
5. Professor E. Hull.—To exhibit a small block of magnetically polar diorite.
6. A. C. G. Cameron.—Note on the recent exposures of Kellaway's Rock, at Bedford.
7. G. R. Vine.—Polyzoa of the Red Chalk.

Papers read in Section F 104
1. William Botly.—Agricultural Statistics.
2. Professor Fream.—Methods of Forecasting the Yield of Crops.
3. D. G. Hoey.—Improved Dwellings for the Poor.
4. Hyde Clarke.—The Increase in Europe and America of Nominal or Fictitious Capital.

PAGE
Papers read in Section G. 106
1. Report on Investigations of Estuaries by means of Models.
2. Report on the Development of Graphic Methods.
3. A. R. Liddell.—Ships for the Carriage of Petroleum.
4. M. Holzapfel.—The Corrosion and Fouling of Ships.

Excursions to Places of Interest 110
Durham University, Special Convocation at 110
"The Forth Bridge," Lecture on, by Mr. Baker 126
Fifth day's proceedings (Monday) 131
Papers read in Section A 131
1. Report of the Committee on Differential Gravity Meters.
2. Report of the Committee on Meteoric Dust.
3. Report of the Committee on Solar Radiation.
4. Professor McLeod, F.R.S.—On the Black-bulb Thermometer in Vacuo.
5. Report of the Committee on Magnetic Observations.
6. Professor Leonhard Weber.—On Atmospheric Electricity.
7. Magnus Maclean and Makita Goto (Communicated by Sir W. Thomson, F.R.S.).—Electrification of Air by Combustion
8. Professor C. Michie Smith.—Notes on Atmospheric Electricity and the Use of Sir W. Thomson's Portable Electrometer.
9. Professor Leonhard Weber.—On Photographs of Lightning.
10. A. W. Clayden.—On Dark Flashes of Lightning.
11. Report of the Committee on the Ben Nevis Meteorological Observations.
12. Professor Cleveland Abbe.—The Determination of the Amount of Rainfall.
13. Professor Piazzi Smyth.—Hygrometry in the Meteorological Journal.
14. Report of the Committee on Underground Temperature.
15. Report of the Committee on the Seasonal Variations in the Surface Temperature of Water.
16. Dr H. C. Sorby.—On the Temperature of the Tidal Estuaries of the South-East of England.
17. T. J. Murday.—Apparatus for Reading indications of Distant Meteorological Instruments.
18. T. J. Murday.—The Regular Return of Storms.
19. R. E. W. Goodridge.—On the Periodicity of Mild Winters.

Joint Meeting with Section C 133
Professors A. W. Rucker, F.R.S., and T. E. Thorpe, F.R.S.—On the Relation between the Geological Constitution and the Magnetic State of the United Kingdom.

Papers read in Section B 133
1. Report of the Committee on the Bibliography of Solution.
2. Report of the Committee on the Properties of Solutions.
3. Report of the Committee on the Absorption Spectra of Pure Compounds.
4. Report of the Committee on the Action of Light on the Hydracids.
5. Report of the Committee on the Silent Discharge in Oxygen.
6. Report of the Committee on the Bibliography of Spectroscopy.
7. Dr. Arthur Richardson.—A new form of self-registering Actinometer.
8. Professor H. B. Dixon, F.R.S.—Explosion of a mixture of Hydrogen Chlorine and Oxygen.
9. Professor H. B. Dixon, F.R.S., and J. A. Harker.—On the action of Light on dry Hydrogen and Chlorine.
10. Dr. A. P. Laurie.—On Artists' Colours.
11. Dr. William Newton.—Specific and Latent Heats in relation to the Combining Heats of the Elements.
12. Dr. A. Scott.—Composition of Water by Volume.
13. P. Braham.—A Spectroscope without a Lens.

Papers read in Section C. 134
1. W. A. E. Ussher.—The Devonian Rocks of Great Britain.
2. John Marley and Professor G. A. Lebour.—Sketch of the rise and progress of the Cleveland and South Durham Salt Industry, and on the extension of the Durham Coal-field.
3. C. E. De Rance.—Report of the Committee on the Circulation of Underground Waters.
4. Dr. D. Embleton.—On the spinal column of *Loxomma Allmanni* from the Northumberland Coal-field.
5. Dr. R. Laing.—The Bone Caves of Cresswell, with the recent discovery of an extinct feline (*Felis brevirostris*) new to Great Britain.
6. Dr. R. H. Traquair.—On the Devonian Fishes of Canada.
7. A. Smith Woodward.—On the Occurrence of the Devonian Ganoid *Onychodus* in Spitzbergen.
8. A. Smith Woodward.—Notes on some new and little-known British Jurassic Fishes.
9. Professor A. W. Rücker and Professor T. E. Thorpe.—On the Relation between the Geological Constitution and the Magnetic State of the United Kingdom.

Papers read in Section D 137
1. Debate on "Specific Characters as Useful and Indifferent," opened by Prof. G. J. Romanes, F.R.S.
2. Rev. Canon Norman.—The limit between the Continental and Abyssal Marine Fauna.
3. Professor G. Gilson.—The secretion of Silk by the Silkworm.
4. Sir William Turner, F.R.S.—On the placentation of the Dugong.
5. Dr. J. Symington.—Observations on the Myology of the Gorilla and Chimpanzee.
6. Professor W. A. Herdman.—On the Structure and Function of the Dorsal Papillæ in Nudibranchs.
7. Professor W. A. Herdman.—On the Electric Light as a means of attracting Marine Animals.
8. Professor A. C. Haddon.—On the caudal respiration of *Periophthalmus*.
9. Dr. G. Sims Woodhead and R. W. Gray.—On the histology of the stomach of the Narwhal, and its bearing on Turner and Max Weber's observations and nomenclature.
10. R. Irvine and G. Sims Woodhead.—On the Secretion of Carbonate of Lime by Animals.
11. W. S. Anderson.—The solubility of Carbonate of Lime in Fresh and Sea Water.

Papers read in Section E. 143
1. Karl Lumholtz.—The Geography and Resources of Central Queensland.
2. Alexander Cook.—British North Borneo.
3. H. Guillaume.—Recent Explorations in Peru and Bolivia.
4. E. G. Ravenstein.—Geographical Co-ordinates in the Valley of the Upper Nile.
5. R. Sullivan.—The Resources of Siberia and the Practicability of the Northern Sea Route.
6. Dr. Fridtjof Nansen.—Greenland.

Papers read in Section F 152
1. L. L. Price.—The Relations between Industrial Conciliation and Social Reform.
2. R. Spence Watson.—The Difficulties of Arbitration.
3. Sidney Webb.—The Relation between Wages and the remainder of the Economic Product.
4. Report of the Committee on the Teaching of Science in Elementary Schools.
5. Sir Benjamin Browne.—Apprenticeship in the Engineering and Shipbuilding Trades.
6. Dr. J. H. Rutherford.—Technical Education.
7. E. J. Watherston.—On Manual, or some form of Technical Instruction, a Necessary Element of a Compulsory System of Education.

Papers read in Section G 156
1. Major-General Webber.—The Distribution of Electricity from Accumulators.
2. Killingworth Hedges.—Precautions necessary in the use of Transformers.
3. J. Swinburne.—The Design of Transformers.
4. George Forbes.—Electric Launches on the Thames.
5. Edward Manville.—Series Electrical Traction (Northfleet Tramways).
6. W. H. Preece.—Telephonic Communication between London and Paris.
7. W. Webster.—Electrical Purification of Sewage.

Papers read in Section H 160
1. Report of the Anthropological Notes and Queries Committee
2. Report of the Anthropometric Laboratory Committee.
3. Dr. J. G. Garson.—Exhibition of a new Anthropometric Instrument specially designed for the use of Travellers.
4. Francis Galton, F.R.S.—Exhibition of an Instrument for Measuring the Reaction time to Sight and Sound Signals.
5. Dr. Thomas Wilson.—The Smithsonian Institution in the U.S. of America, and its work relating to Anthropology.
6. H. H. Risley.—The Study of Ethnology in India.
7. Professor A. C. Haddon.—On some former Customs and Beliefs of the Inhabitants of the Islands in Torres Straits.
8. Edward Beardmore.—Anthropological Notes collected at Mowat, Daudai, New Guinea.
9. Dr. MacLaurin.—The British Race in Australia.
10. Dr. Beddoe, F.R.S.—Observations on the Natural Colour of the Skin in certain Oriental Races.

PAGE

11. R. W. Felkin, M.D.—The Normal Temperature of the Soudanese, Negroes, and Europeans in Tropical Africa.
12. R. W. Felkin, M.D.—The differences of Sensibility between Europeans and Negroes and the Effect of Education in increasing the Sensibility of Negroes.

Lecture in Drill Hall by Mr. Walter Gardiner—"How Plants Maintain themselves" 164
Committee of Recommendations 166
Sixth Day's Proceedings (Tuesday) 168
Papers read in Section A 168

1. F. T. Trouton—Some Experiments on Radiation with Professor Hertz's Mirrors.
2. Report of the Committee on Electrical Standards.
3. Report of the Committee on Electrolysis.
4. W. N. Shaw—Report on the present state of our knowledge in Electrolysis and Electro-chemistry.
5. Professor A. Schuster, F.R.S.—On the Discharge of Electricity through Gases.
6. Professor A. M. Worthington.—On the Discharge of Electrification by Flames.
7. Professor Oliver J. Lodge, F.R.S.—On the Failure of Metal Sheets to Screen off the Electrostatic Effect of Moving or Varying Charges.
8. Professr J. Blyth.—On a New Form of Current-Weigher.
9. Professor S. P. Thompson.—On a Phenomenon in the Electro-chemical Solution of Metals.
10. J. Wilson Swan.—On Chromic Acid as a Depolariser in Bunsen's Battery.
11. Professor J. Perry, F.R.S.—To exhibit Standards of Self-induction.
12. Professor J. Perry, F.R.S.—A Twisted-strip Voltmeter.
13. W. H. Preece, F.R.S.—On the Relative Effects of Steady and Alternate Currents on Different Conductors.
14. Professor G. Forbes, F.R.S., and W. H. Preece, F.R.S.—A New Thermometric Scale.
15. J. T. Bottomley, F.R.S., and Sir Archibald Campbell, of Blythswood, Bart.—To exhibit Leyden Jars with Multiple Fracture.
16. Professor S. P. Thompson.—On Sparkless Electro-magnets.
17. Dr. J. H. Gladstone, F.R.S., and Dr. W. H. Perkin, F.R.S.—On the Correspondence between the Molecular Refraction, Dispersion, and Magnetic Rotation of Carbon Compounds.
18. Dr. H. E. J. du Bois (communicated by Sir William Thomson, F.R.S.)—On Kerr's Magneto-optic Phenomenon: its laws and application to measuring purposes.

Papers read in Section B 169

Joint Discussion of Sections B and G, on Blast Furnace Practice.

1. Report of the Committee on Isomeric Naphthalene Derivatives.
2. Report of the Committee on the Formation of a Uniform System of Recording the Results of Water Analysis.
3. Professor Percy F. Frankland, Grace C. Frankland, and J. J. Fox.—Contributions to the study of Pure Fermentation.
4. S. A. Sworn, B.A.—The Constitution of the Aromatic Nucleus.
5. S. A. Sworn, B.A.—The Reaction of Benzoquinone with Potassium Cyanide.
6. J. B. Hannay.—A new White Lead.
7. Dr. Isaac Ashe.—Dimidium: an attempt to represent the Chemical Elements by Physical Forms.
8. P. J. Hartog, B.Sc.—Researches on Sulphites.
9. Dr. J. B. Cohen.—Metallic Aluminium as a Chemical Reagent.

Papers read in Section C. 172

1. Professor A. C. Haddon.—Notes on the Geology of Torres Straits.
2. G. W. Lamplugh.—Report on an Ancient Sea Beach near Bridlington.
3. Dr. H. W. Crosskey.—Report on Erratic Blocks.
4. W. Whitaker.—On a Deep Channel filled with Drift in the valley of the Cam, Essex.
5. H. H. Howorth.—Are the extreme Glacial views developed by Agassiz and his scholars consistent with our present geological knowledge?
6. G. W. Lamplugh.—Note on a new locality for the Arctic Shellbeds of the Basement Boulder Clay on the Yorkshire Coast.
7. H. H. Howorth.—Did the great rivers of Siberia flow southwards and not northwards in the Mammoth age?
8. E. B. Dorsey.—On the Witwatersrande Gold Fields.

9. A. Bell.—Report on the Manure Gravels of Wexford.
10. Professor F. Clowes.—On Waterbox Deposits and their bearing on the cementing material of Rocks.

Papers read in Section D. 175

ZOOLOGICAL DEPARTMENT.

1. Dr. Traquair, F.R.S.—Restoration of *Asterolepis maximus* (Agassiz) with remarks on the Zoological affinities of the Pterichthyidæ.
2. I. C. Thompson.—On some new and rare Copepoda recently found in Liverpool Bay.
3. Professor A. Fraser.—On Photography as an aid in Anatomical, Histological, and Embryological work.
4. Professor T. Oliver.—Our Local Industries in their Social and Pathological Aspect.
5. C. V. Riley.—Note on the Importation and Colonization of Parasites and other Natural Enemies of Insects injurious to Vegetation.
6. B. W. Gibsone.—The Uses of the Testaceæ or Conchiferous Molluscs in Nature, Science, and Arts.
7. G. C. Bourne.—Report on the work done at the Laboratory of the Marine Biological Association in the past year.
8. G. Brook.—The Morphology of the Antipatharia.
9. R. J. Anderson.—Some points of structural and functional resemblance in the anterior and posterior limbs of Mammals.

BOTANICAL DEPARTMENT.

1. Professor M. M. Hartog.—On the state of the water in living Protoplasm.
2. Professor S. H. Vines, F.R.S.—Epinasty and Hyponasty.
3. Dr. D. H. Scott.—On some Recent Progress in our Knowledge of the Anatomy of Plants,
4. P. Sewell.—On Botanical Gardens for Elementary Schools.
5. M. C. Potter.—The Protection of Buds against the Sun.
6. M. C. Potter.—The Biology of *Erythrina lithosperma.*
7. Professor Fream.—On the Effect of Root-section on the Vitality of Pasture Plants.
8. Professor M. M. Hartog.—On a Monadine Parasitic on *Saprolegniæ.*
9. Dr. F. W. Oliver.—On Davidia, a new genus from Central China.
10. Dr. F. W. Oliver.—On a case of Mycorhiza.
11. Miss Ewart.—On Floral Contrivances in the genus *Thesium.*
12. Professor Marshall Ward, F.R.S.—On the development of a Sclerotium from *Botrytis.*
13. Professor Marshall Ward, F.R.S.—On the Recognition, by means of Microscopic Sections, of Woods dug by Mr. Spurrell from the Forest Beds of the Thames.

Papers read in Section E. 179

1. Joseph Thomson.—Report to the Committee appointed to investigate the Geography and Geology of the Atlas Ranges in the Empire of Morocco.
2. Basil Thomson.—Exploration of New Guinea and Neighbouring Islands.
3. Theodore Bent.—The Bahrein Islands.
4. Sir Lambert Playfair.—The Jedars and other objects of interest in the District of Tiaret and Algeria.
5. A. W. Clayden.—Models to Illustrate the Action of Winds on Ocean Currents.
6. J. G. Colmer, C.M.G.—The N.W. Territories of Canada.
7. Dr. Guppy.—Western Java.

Papers read in Section F 183

1. Professor E. Hull.—Diagram showing the rate of Production of Coal during the present Century.
2. W. Vallance.—Poor Law Progress and Reform, as exemplified in the administration of an East London Union.
3. Rev. W. Bury.—Poor Law Administration and Reform.
4. Rev. W. Moore Ede.—National Insurance.
5. Rev. H. V. Mills.—Home Colonisation.
6. Report of the Committee on Variations of the Monetary Standard.
7. Report of the Committee on the Statistics of the Precious Metals.

Papers read in Section G. 187

SUB-SECTION I.

1. Sir Lowthian Bell.—Blast Furnace Practice. (Joint Discussion with Section B.)
2. Sir Douglas Galton, K.C.B.—Chemin de fer glissant.
3. Prof. W. C. Unwin.—Strength of Alloys at Different Temperatures.
4. C. E. De Rance.—Records of River Volumes and Flood Levels.
5. W. W. Phipson.—Central Station Heating and Power Supply.

PAGE

6. M. Godillot.—An Automatic Stoker.
7. Lieut.-Col. W. J. Engledue, R.E.—The Hopcraft Smokeless Furnace.

SUB-SECTION II.

1. Alexander P. Trotter.—On a Curve Ranger.
2. E. B. Dorsey.—Comparison of the Working of British and American Railways.
3. T. H. Brigg.—Draught of Horses.
4. W. H. Wheeler.—Application of the Transporting Power of Water to the Improvement of Rivers.

Papers read in Section H 192

1. Dr. Fridtjof Nansen.—The Esquimaux.
2. Rev. G. Rome Hall.—Northumberland in Prehistoric times.
3. Professor Sir W. Turner, F.R.S.—On Implements of Stag's Horn associated with Whales' Skeletons found in the Carse lands of Stirling.
4. G. J. Romanes, F.R.S.—The Origin of Human Faculty.
5. Bernard Hollander.—On the relations between Brain-Functions and Human Character.
6. Professor Frazer.—A new method of illustrating the Topographical Anatomy of the Brain.
7. George Weddell.—Notes on Classification in Sociology.
8. S. B. J. Skertchley.—Fire-making in North Borneo.
9. S. B. J. Skertchley.—On some Borneo Traps.
10. James Macdonald.—Manners, Customs, and Superstitions of South African Tribes.
11. Report of the Occupations Committee.
12. Report of the North-Western Tribes of Canada Committee.
13. Report of the Prehistoric Inhabitants Committee.

Conversazione, The Second ....
Delegates, Conference of ....
Scandinavian Celebrities, Banquet to ....
Seventh day's proceedings (Wednesday) ....
Papers read in Section A 204

1. Report of the Committee on the Nomenclature of the Fundamental Units of Mechanics.

PAGE

2. W. W. Haldane Gee and Dr. A. Harden.—Stereometry.
3. W. W. Haldane Gee and H. L. Terry.—The Specific Heat of Caoutchouc.
4. F. T. Trouton.—On the Temporary Thermo-currents in Iron.
5. Prof. W. F. Barrett.—On the Recalescence of Iron.
6. J. Gamgee.—The Cardium, illustrating the True Nature of Prime Movers.
7. J. Spiller.—An Experiment in Colour Blindness.
8. Walter Gardiner.—On a New Method of Printing Photographic Negatives, employing Living Leaves in place of Sensitive Paper.
9. J. Hancock.—On a Mode of Photography.
10. Dr. A. Richardson.—A New Form of Self-Registering Actinometer.
11. P. Braham.—The Action of Magnetism on Photographic Plates.
12. P. Braham.—Physical and Chemical Constitution of Comets and Meteorites.
13. Report of the Committee on Certain Proposals relative to the Unification of Time.

Papers read in Section C 207

1. J. Starkie Gardner.—Report on the Eocene Plants of the Isle of Wight.
2. Professor A. H. Green.—A word or two about the so-called Concretions in the Magnesian Limestone of Durham.
3. W. Topley.—The Work of the Geological Survey in Northumberland and Durham.
4. R. Tiddeman.—On concurrent Faulting and Deposit (Craven, Yorkshire), with a note on Carboniferous Reefs.

Grants for Scientific Purposes, List of 208
Concluding General Meeting 209
"Women's Dress": Lecture by Mrs. Stopes 213
The Eighth Day—Final Excursions 218

WELLCOME INSTITUTE
LIBRARY

Printed by WALTER SCOTT, *Felling, Newcastle-on-Tyne.*

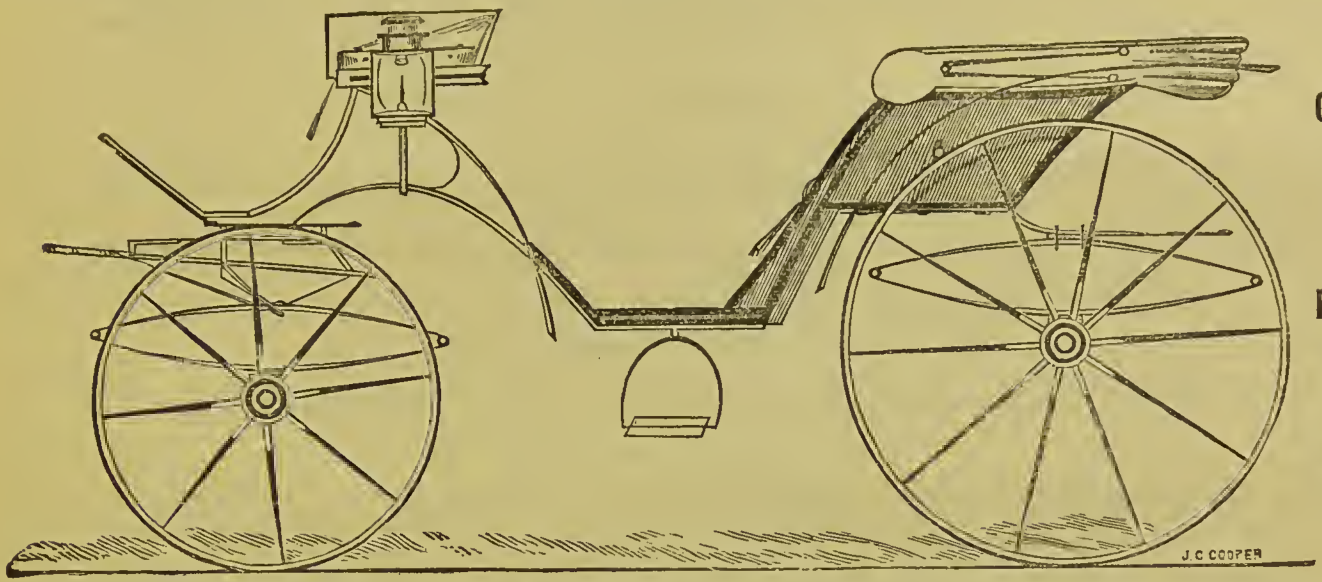
ATKINSON & PHILIPSON

ESTABLISHED 1794.

Carriage and Harness Manufacturers,

COACHMAKERS BY SPECIAL WARRANT TO H.R.H. THE PRINCE OF WALES.

27 PILGRIM STREET, NEWCASTLE-UPON-TYNE.



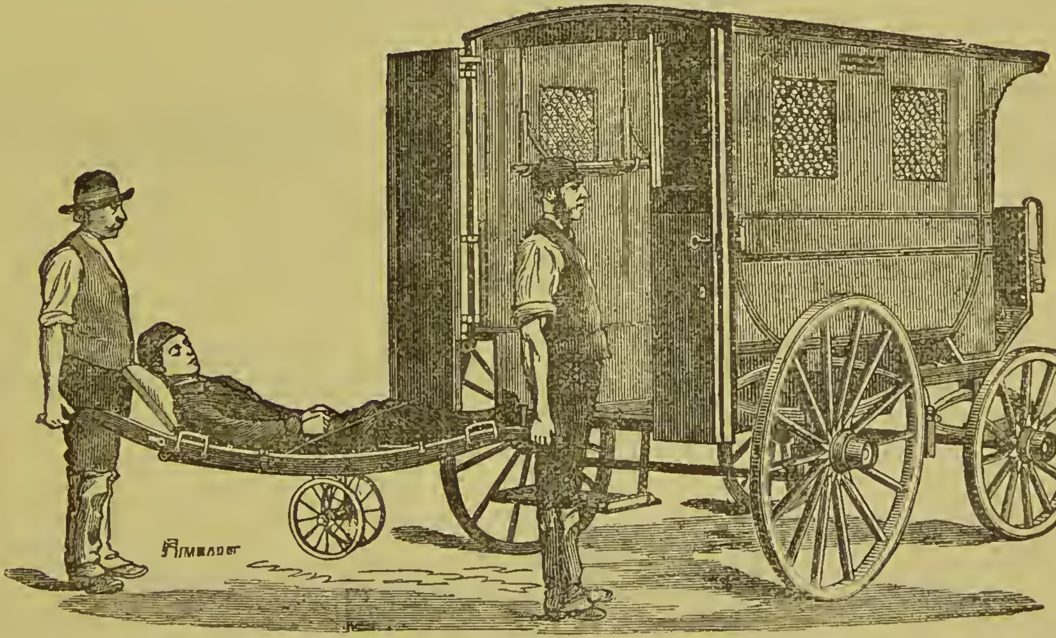
500 CARRIAGES in STOCK.

Fashionable Designs.

Moderate Prices.

DESIGNERS AND MANUFACTURERS OF THE PHILIPSON AMBULANCE CARRIAGES AND STRETCHERS.

Supplied to Royal Infirmary, Manchester; Royal Infirmary, Leeds; Wellington College; Corporations of Sheffield, Dundee, Ealing, Newcastle, etc., etc.



Supplied to The M. S. & L. Railway Co., Newcastle Police, Tyne Hospital Ship, West Cumberland Infirmary, Hawthorn, Leslie, & Co., and many Mines and Manufactories.

ILLUSTRATED CATALOGUES AND DRAWINGS POST FREE.

CARRIAGES SOLD ON THE HIRE-PURCHASE SYSTEM.

VISITORS are invited to call and inspect the Manufactory and Show-Rooms.

THE GREAT NEWSPAPER OF THE NORTH.

NEWCASTLE CHRONICLE

ESTABLISHED 1764.

PUBLISHED MORNING, EVENING, WEEKLY, & MONTHLY.

CIRCULATION:

Over Half-a-Million Copies Weekly.

Over Twenty-six Million Copies Yearly.

NEWCASTLE DAILY CHRONICLE

PRICE ONE PENNY.

NEWCASTLE WEEKLY CHRONICLE

PRICE TWOPENCE.

THE EVENING CHRONICLE

PRICE ONE HALFPENNY.

THE MONTHLY CHRONICLE

PRICE SIXPENCE.

CHIEF OFFICES—WESTGATE ROAD, NEWCASTLE-ON-TYNE.

THE ELSWICK SCIENCE SERIES.

The Elswick Series is intended to supply Teachers and Students with good books, void of "cram." They will be issued as rapidly as is consistent with the caution necessary to secure accuracy. A great aim will be to adapt them to modern requirements and improvements, and to keep abreast with the latest discoveries in Science, and the most recent practice in Engineering.

Crown 8vo, Cloth, Price 3s. 6d. each.

PRACTICAL AND THEORETICAL TRIGONOMETRY.

By HENRY EVERS, LL.D., Author of "Steam," etc.

MANUAL OF STEAM AND PRIME MOVERS.

By HENRY EVERS, LL.D., Author of "Steam,"
"Navigation," etc. [*Now Ready.*

In the Press.

DESCRIPTIVE GEOMETRY.

By Professor T. H. EAGLES, M.A., Author of "Constructive Geometry of Plane Curves," etc.

London: WALTER SCOTT, 24 Warwick Lane, Paternoster Row.

Crown 8vo, Cloth. Price 3s. 6d. per Vol.; Hlf. Mor. 6s. 6d.

THE
CONTEMPORARY SCIENCE SERIES.

EDITED BY HAVELOCK ELLIS.

Most of the vols. will be illustrated, containing between 300 *and* 400 *pp. The first vol. will be issued on Oct.* 25, 1889. *Others to follow at short intervals.*

THE CONTEMPORARY SCIENCE SERIES will bring within general reach of the English-speaking public the best that is known and thought in all departments of modern scientific research. The influence of the scientific spirit is now rapidly spreading in every field of human activity. Social progress, it is felt, must be guided and accompanied by accurate knowledge,—knowledge which is, in many departments, not yet open to the English reader. In the Contemporary Science Series all the questions of modern life—the various social and politico-economical problems of to-day, the most recent researches in the knowledge of man, the past and present experiences of the race, and the nature of its environment—will be frankly investigated and clearly presented.

The first volumes of the Series will be:—

THE EVOLUTION OF SEX. By Prof. PATRICK GEDDES and J. ARTHUR THOMSON. With 90 Illustrations, and about 300 pages. [*Ready 25th October.*

ELECTRICITY IN MODERN LIFE. By G. W. DE TUNZELMANN. With 88 Illustrations. [*Ready 25th November.*

THE ORIGIN OF THE ARYANS. By Dr. ISAAC TAYLOR. With numerous Illustrations. [*Ready 25th December.*

Other volumes to follow at short intervals, including "Bacteria and their Products," "The Evolution of Marriage," "The Development of Electro-Magnetic Theory," "The Science of Fairy Tales," "Capital and Interest," "Sanity and Insanity," "Manual Training," "Evolution and Disease," "Industrial Development," etc.

The following Writers, among others, are preparing volumes for this Series:—

Prof. G. F. Fitzgerald, Prof. J. Geikie, G. L. Gomme, E. C. K. Gonner, Prof. J. Jastrow (Wisconsin), E. Sidney Hartland, Prof. C. H. Herford, J. Bland Sutton, Dr. C. Mercier, Sidney Webb, Dr. Sims Woodhead, Dr. C. M. Woodward (St. Louis, Mo.), etc.

LONDON: WALTER SCOTT, 24 WARWICK LANE, PATERNOSTER ROW.